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# MYCOLOGIA

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VOLUME XXXVIII, 1946

CONSISTING OF I-V+718 PAGES.  
INCLUDING FIGURES

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# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXVIII JANUARY-FEBRUARY, 1946 No. 1

## A CLAMP-BEARING FUNGUS PARASITIC AND PREDACEOUS ON NEMATODES

CHARLES DRECHSLER<sup>1</sup>

(WITH 7 FIGURES)

Among 10 Hyphomycetes which in a paper (12) published 4 years ago I set forth as attacking nematodes after the manner most familiar in such fungous parasites, that is, through invasion by means of hyphae resulting from the germination of conidia affixed to the animal host, were included 2 species whose filaments bore clamp-connections characteristic of various groups within the Basidiomycetes. Owing to some minor differences, particularly in their sterigmata, the 2 species could not both be aptly referred to any one mucedinaceous genus then known. As assignment to separate genera would almost certainly have obscured the intimate kinship of the 2 species, a new genus, *Nematoctonus*, was erected for them; this disposition being deemed all the more advantageous since it would serve to bring into relief how unusual the biological relationship here concerned—parasitism on animals normally free-living and motile from the moment of hatching until the approach of death—was among fungi belonging in the Basidiomycetes. The diagnosis of the new genus was intentionally phrased so as to make provision not only for the 2 parasitic species then described under

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the binomials *N. tylosporus* and *N. leiosporus*, but also for a third form generally similar to them in its production of conidia and clamp-connections, as well as in its habitual subsistence on nematodes, but differing significantly in attacking eelworms for the most part in a predaceous manner—that is, by holding the animals through adhesion to specialized vegetative organs, eventually to extend into the helpless captives assimilative hyphae of mycelial origin. Since the third form had been available for examination only in cultures obtained from Hawaii, which when received by ordinary mail were too old to allow preparation of satisfactory figures, it was left unnamed in the hope that an accession of younger material might later make possible a better description. This hope has so far not been fulfilled, owing to failure of the fungus to appear in such cultures as I have subsequently had occasion to prepare from decaying plant detritus collected mostly in Virginia, Maryland, Delaware, Maine, Wisconsin, and Colorado; though 2 additional clamp-bearing species parasitic on nematodes have come to light and have been described (13) under the binomials *N. pachysporus* and *N. leptosporus*. More recently, again, a sixth member of the genus, which, besides attacking eelworms parasitically, operates very destructively in a predaceous manner much like the Hawaiian species, has been observed under favorable conditions and in adequate abundance.

The fungus in question was obtained from 2 collections of friable vegetable refuse gathered by W. J. Zaumeyer near Greeley, Colorado, in October, 1944; one of the collections consisting mainly of partly decayed cucumber (*Cucumis sativus* L.) vines and partly decayed lilac (*Syringa* sp.) leaves, while the other was composed largely of decayed remnants of tamarisk (*Tamarix* sp.) leaves, cottonwood (*Populus* sp.) leaves, and oleaster (*Elaeagnus angustifolia* L.) leaves. In accordance with routine procedure pinches of material from both collections were planted in Petri dishes on maize meal agar already well permeated with oömycetous mycelium; opportune utilization being made, in this instance, of old cultures of *Pythium arrhenomanes* Drechs. and *P. undulatum* Petersen *sensu* Dissmann. Before long a flourishing population of eelworms was present in all the cultures, with the result that after about 10 days the predaceous hyphomycetes *Arthrobotrys*

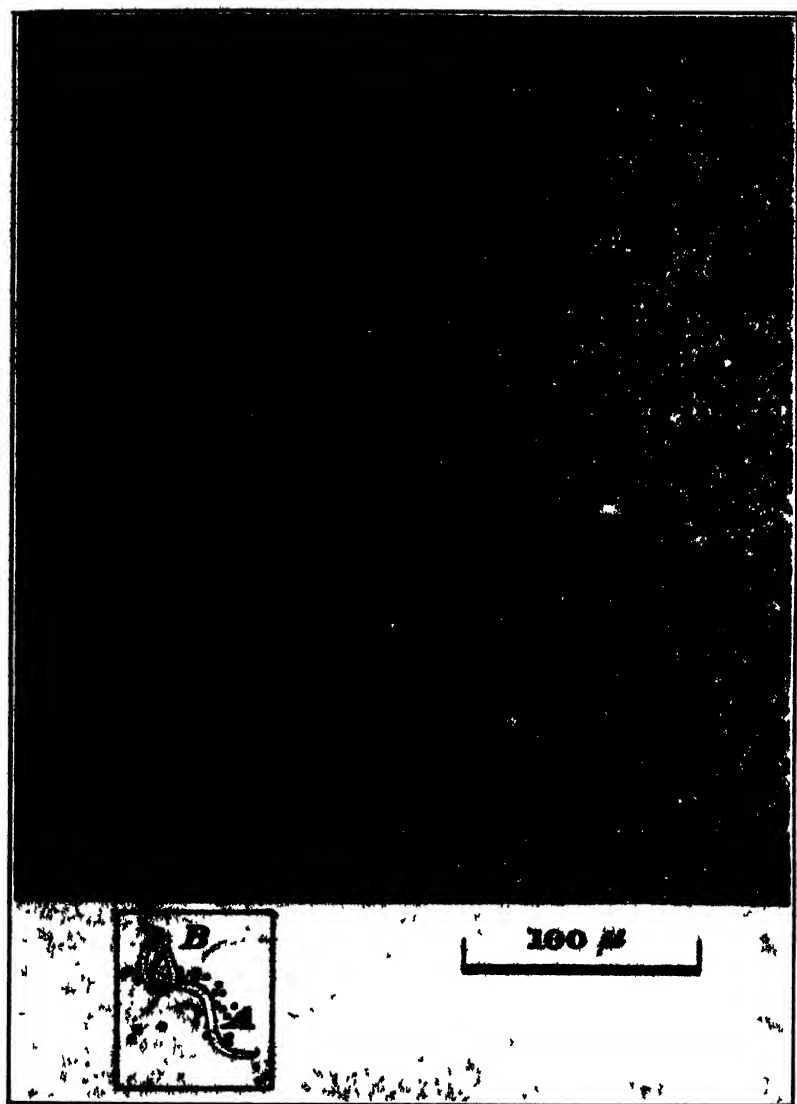


FIG. 1. *Nematoclonus haptocladus*  $\times 300$ .

*oligospora* Fres. and *A. arthrobotryoides* (Berl.) Lindau, as also the hyphomycetous parasite *Harposporium anguillulae* Lohde, were developing extensively. Usually it was not until these familiar hyphomycetes had been active for several days that the new clamp-bearing fungus could be found beginning to destroy eelworms in numbers sufficient to arrest attention, though its destructiveness in many cultures soon became very severe. A nematode identified as an undescribed species of *Panagrolaimus*,<sup>2</sup> which predominated numerically over all other species, was often found killed in spectacular quantity. A stylet-bearing nematode identified as *Paraphclenchus pseudoparietinus* Micoletzky<sup>2</sup> and several species of the genera *Rhabditis* and *Mononchus* incurred destruction in a measure corresponding approximately to their lesser abundance.

While as a general rule the predaceous fungi, including both the nematode-capturing hyphomycetes and the nematode-capturing Zoöpagaceae, begin their visible development in Petri plate cultures containing deposits of decaying plant material by extending mycelial filaments from the opaque deposits into the surrounding transparent agar medium, the clamp-bearing fungus more often makes its initial appearance in growing out of dead nematodes (FIG. 1, A) lying at some distance—frequently 10 to 20 mm.—from the nearest mass of vegetable detritus. In their earlier stages of development the mycelial filaments growing out into the clear culture medium offer no unusual features (FIG. 2, A). Except for the cross-walls associated with the clamp-connections studding them at moderate intervals, they contain few septa. The longer hyphae show moderate branching at rather wide angles; some, though not all, of the branches manifestly arising from individual clamps. Neither vacuoles nor granular constituents are at all abundant in young hyphae; so that the protoplasmic contents present a rather clear, nearly homogeneous appearance.

The commonplace morphology just described pertains more especially to mycelial elements formed under the surface of agar substratum, and consequently is displayed on a greater scale in

<sup>2</sup> For identification of these species I am indebted to Dr. G. Steiner, Principal Nematologist, Division of Nematology, Plant Industry Station, Beltsville, Maryland.

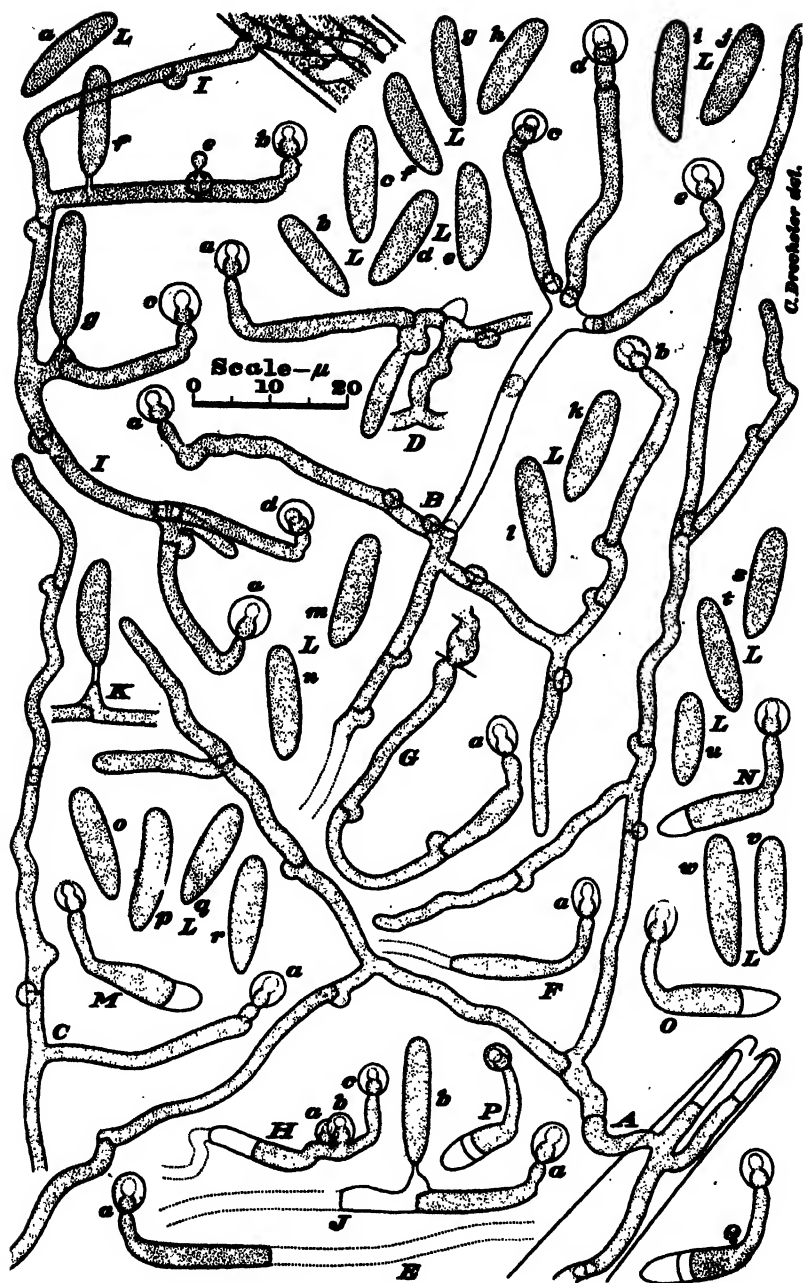
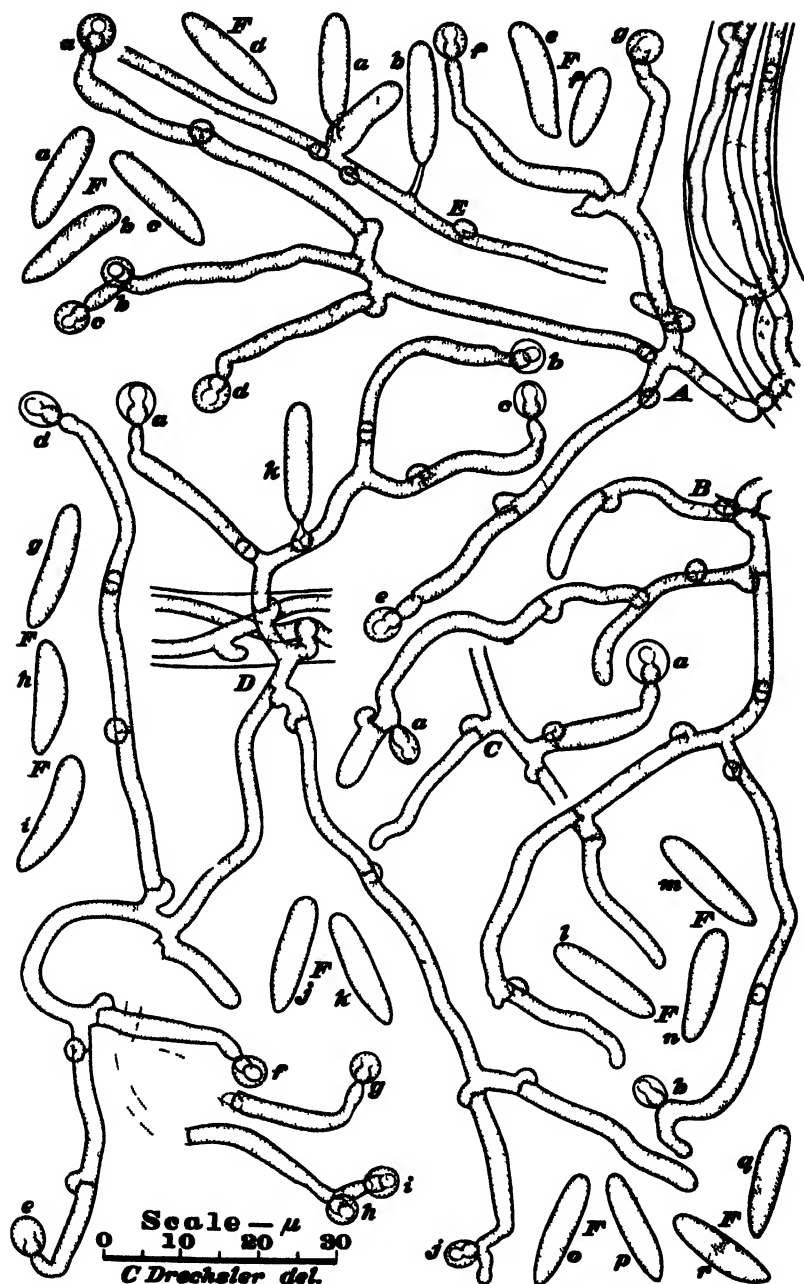


FIG. 2. *Nematoclonus haptocladus*.

instances where the nematode has happened to succumb in a deeply submerged position than in instances where it succumbed on the surface. Once the hyphae from a submerged animal reach the surface they continue their development for the most part procumbently, and then are capable of undergoing the same distinctive modification (FIG. 2, *B*) which hyphae growing out from animals lying on the surface can achieve with little preliminary expenditure of their substance (FIG. 3, *A, B*). To accomplish this modification the prostrate axial filament, as also its prostrate branches, stops elongating procumbently, and gives rise abruptly from its tip to a short, erect or ascending process terminating in a glandular cell that soon is surrounded by a transparent adhesive secretion (FIG. 2, *B, a-e*; *C, a*; *D, a*; *E, a*; *F, a*; *G, a*; *H, a-c*; *I, a-d*. FIG. 3, *A, a-g*; *B, a, b*; *C, a*; *D, a-j*. FIG. 4, *A, a, b*). The glandular cell usually has a shape somewhat like the Arabic numeral 8. Generally its proximal lobe is noticeably wider than its distal lobe, and appears to be surrounded by thicker, more substantial membrane. As the boundary of the distal lobe, especially at the rounded tip, is often only vaguely discernible, it may be surmised that this lobe is the more directly active one in the elaboration of adhesive material. When viewed under the microscope, in a moist preparation covered with a cover glass, the adhesive drop shows a distinct boundary, as if it were surrounded by a thin peripheral film. Sometimes short rod-like markings appear to extend radially inward from the peripheral contour of the droplet (FIG. 2, *E, a*. FIG. 3, *A, a-g*; *B, a*; *D, c-j*). It is quite possible that these markings may represent only minute folds in the peripheral film such as might readily result from the pressure of the overlying cover glass. Not infrequently a predaceous branch, after putting forth one adhesive body, will elongate slightly to put forth a second (FIG. 3, *A, b, c*; *D, h, i*. FIG. 4, *A, a, b*); and occasionally elongation is repeated in the development of a third adhesive body (FIG. 2, *H, a, b, c*). This rejuvenation of predaceous branches has an obvious parallel in the repeated elongation of the outgrowth put forth by abjoined conidia of *Nematoctonus pachysporus*.

As the glandular cells with their envelopes of adhesive secretion are borne aloft in the air 2 to 8  $\mu$  above the substratum they stand out in bold relief when cultures containing them are examined

FIG. 3 *Nematoctonus haptocladus*

microscopically in an uncovered state by means of a dry objective (FIGS. 1, 5, 6). Owing to their raised position they adhere only to nematodes moving along on the surface of the culture. Small eelworms, as, for example, young specimens of the undescribed *Panagrolaimus* species mentioned, are usually held securely despite all struggles, even when attached only by a single adhesive branch (FIG. 7, A, a); and somewhat larger animals are frequently held captive if two (FIG. 1, B) or more branches become fastened upon them. Like the nematode-capturing Zoopagaceae, but unlike most of the clampless hyphomycetous forms familiarly exemplified in *Arthrobotrys oligospora*, the fungus shows no special development operative in killing or disabling quickly any nematode captured by it. It accordingly delays invasion—certainly invasion on an extensive scale—until the animal has become quiescent from prolonged struggle. A small specimen of *Paraphelenchus pseudo-parietinus*, whose capture happened to come under direct observation, remained capable of some slight movement fully 31 hours later. Forty-eight hours after capture the animal was motionless (FIG. 7, B), though death had probably taken place only a short time earlier, judging from the meager display of assimilative hyphae inside its body.

While the smaller, weaker nematodes are usually held captive on the adhesive branches, the larger and stronger animals more often tear these branches away, and continue moving about, carrying the adhesive organs with them (FIG. 7, C, a-f). Such escape, however, brings little advantage, for the affixed fungous structures penetrate the integument and intrude infective hyphae, eventually killing the fugitives, much as if they had been held captive. Because of the long period required to bring about their disablement, the fugitive animals roam about widely, often entering other areas of infestation and thus becoming burdened with additional predaceous apparatus. In cultures where the fungus was abundant, large specimens of the unnamed *Panagrolaimus* measuring .75 to 1 mm. in length could often be seen encumbered with 15 to 20 adhesive branches; and much more frequently somewhat less robust specimens were found still moving about feebly, though a half-dozen adhesive branches had intruded assimilative hyphae of some length (FIG. 7, C, a-f). Infected eelworms, thus capable of

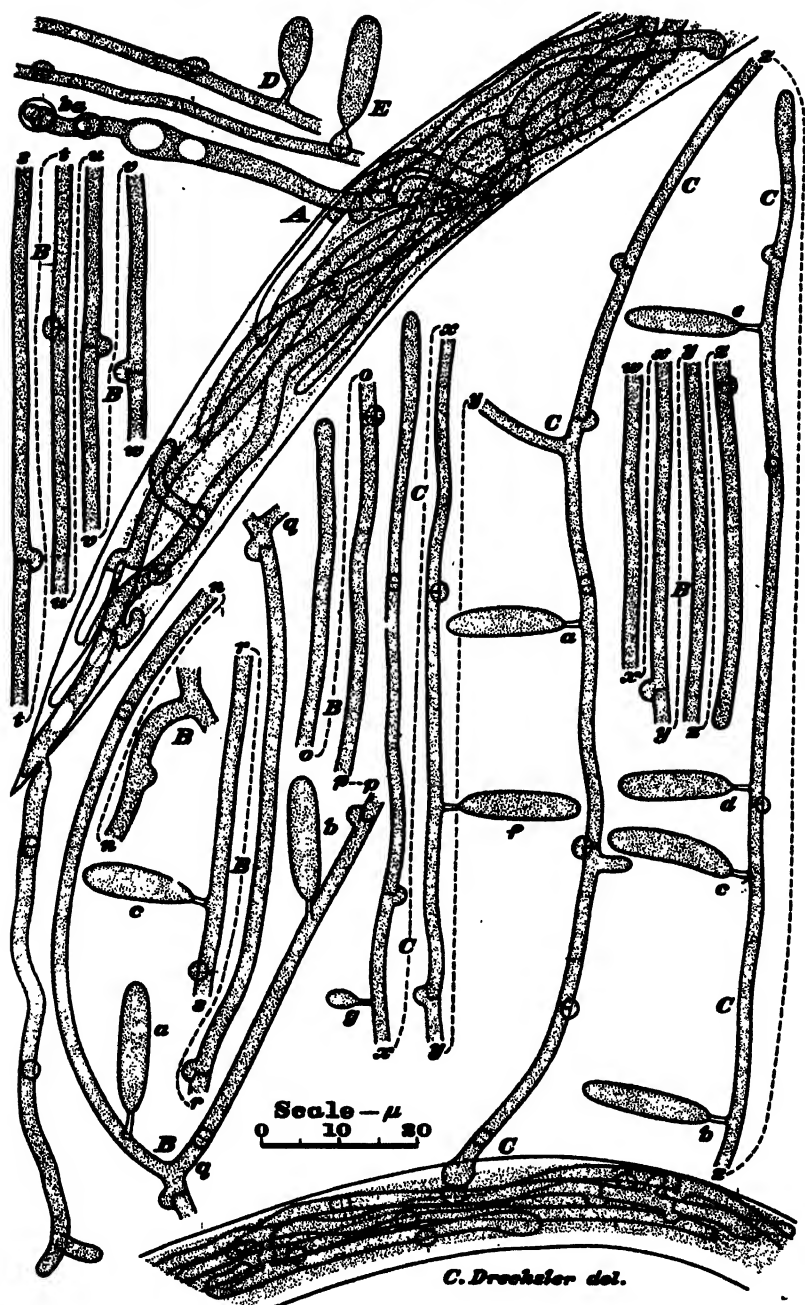
prolonged locomotion are, of course, wont to succumb in scattered positions, much like eelworms killed by fungi attacking wholly after the ordinary manner of parasites. Its failure to hold the more robust nematodes not only explains largely why the fungus often makes its first appearance in Petri plate cultures at a distance from the deposit of decaying material whence it must have originated, but also explains for the most part why nematodes are often found succumbing to it in submerged positions, despite its production of predaceous organs only on the surface of the agar substratum. Again, partly because of the limited mechanical strength of the filaments terminating in adhesive organs, and partly because of the limited elongation of hyphae extended from dead nematodes, flourishing cultures of the fungus show a characteristic distribution of dead and dying eelworms in numerous colony-like groups—the groups including often 5 to 25 small eelworms held captive through adhesion to the abundant predaceous apparatus originating from the body of a conspicuously larger eelworm that had earlier succumbed to invasion from predaceous apparatus which it manifestly had torn off but had not succeeded in shedding.

There are grounds for believing that the frequent tearing away of adhesive organs by the stronger eelworms is a normal and more or less advantageous feature in the development of the fungus. Often a ramifying predaceous hyphal system, still in a fairly youthful condition, undergoes evacuation of protoplasm from intercalary portions, with the result that the adhesive branches distal in relation to these portions remain attached only very weakly by empty membranes so unsubstantial as to be hardly visible (FIG. 2, B, c, d, e; E; H; J. FIG. 3, D, g, h. FIG. 7, A, c, d; B, a, b). Through weakening of the hyphal attachments the fungus achieves a condition analogous to that found in 3 species of the clampless nematode-capturing hyphomycetes—*Dactylella lysipaga* Drechsl., *Dactylella leptospora* Drechsl., and *Dactylaria candida* (Nees) Sacc.—whose predaceous organs, consisting of adhesive knobs and non-constricting rings, are borne on longish, slender, and evidently frail filamentous stalks. As was set forth in an earlier account (8: p. 499–508; p. 523–527), the rings of these species are often torn from their attachments, permitting the ensnared eelworm to proceed on its way. Since the earlier account was written I have



had occasion further to observe in cultures of *Dactylella lysipaga* and *Dactylaria candida* nematodes moving about with predaceous knobs of these fungi adhering externally to them; the knobs in time infecting the encumbered animals and bringing about their death, after a considerable period of motility, in widely scattered positions. Such an extended period of motility after predaceous organs—whether adhesive knobs or non-constricting rings—have been affixed to prey would seem very helpful in spreading the fungus; so that it may well be significant that the 3 clampless hyphomycetes named, much like the clamp-bearing form from Colorado, but wholly unlike most other clampless nematode-capturing hyphomycetes, are not wont to kill eelworms quickly. The frail attachment of predaceous branches consequent to withdrawal of protoplasmic contents from intercalary hyphal parts may thus with some justification be regarded as an adaptation not only advantageous in allowing development of additional predaceous branches from the protoplasmic materials withdrawn, but profitable, moreover, in utilizing the animal's locomotion to extend the region of infestation. It must be admitted, however, that similar extension, though on a lesser scale, would seem to be accomplished quite fortuitously now and then in behalf of clampless hyphomycetes whose predaceous organs are not only attached very firmly to the mycelium but, besides, operate in a manner calculated to inflict death quickly; as, for example, in instances when powerful specimens of *Rhabditis* or *Mononchus*, after tearing off, through sheer violence, the firmly attached constricting rings of *Arthrobotrys dactyloides* Drechsl., *Dactylella bembicodes* Drechsl., or *Dactylaria brochopaga* Drechsl., continue their locomotion for an hour or two, until they are completely disabled.

With respect to its development inside nematodes the fungus shows, in general, little departure from the 4 congeneric species that have previously been described and named. During the earlier stages of invasion the assimilative hyphae are often found conspicuously distended for short distances (FIG. 7, C, b, c, e). Apart from these swollen portions the internal mycelium is usually not clearly discernible until the animal's contents have been largely expropriated (FIG. 4, A, C). It is then revealed as being moderately branched and moderately beset with clamp-connections;

FIG. 4. *Nematoclonus haptocladus*.

many of the branches, indeed, arising from individual clamps. The assimilative hyphae, compared with those of other members of the genus, appear of intermediate coarseness,—being, on the one hand, somewhat wider than the corresponding hyphae of *Nematocionus tylosporus*, *N. leiohypha*, and *N. leptosporus*, and, on the other hand, slightly narrower than the assimilative hyphae of *N. pachysporus*. At first they are filled with protoplasmic contents of rather homogeneous aspect, but as materials are withdrawn to provide for the growth externally of predaceous and conidiophorous filaments, vacuoles appear and evacuation takes place progressively until little is left within the animal's integument except empty hyphal membranes,—the remains of the eelworm being then visible only in faint outline amid the array of adhesive organs elaborated from its fleshy materials (FIG. 1, A). The time required to permeate the body of an eelworm after its death, and to convert its digestible contents into predaceous and conidial apparatus would seem not greatly to exceed the time taken to kill the animal after its capture. Thus, in one observed instance, a captured motionless specimen of the undescribed *Panagrolaimus*, about 325  $\mu$  long, which when first photographed (FIG. 1, B) showed so little internal disorganization that it could have succumbed only a little earlier, was only faintly discernible 48 hours later when it was photographed again (FIG. 5); its fleshy substance having in 2 days been completely expropriated by the fungus, and utilized in the production of approximately 30 predaceous branches and one conidium.

The paucity of reproductive apparatus, relative to the output of predaceous branches from this particular nematode, can hardly be considered unusual for the fungus. The array of approximately 34 adhesive bodies amid which the animal succumbed came from an individual nematode without the supplement even of a single conidium (FIG. 1, A); such failure of sporulation being rather frequent in instances where nematodes of only moderate size die in isolated positions. Where only a few conidia are produced, they usually are borne on sterigmata arising exclusively from prostrate hyphae; some of the sterigmata originating from clamp-connections (FIG. 2, I, e, g; J, b; K. FIG. 3, D, k), others from undifferentiated portions of filament (FIG. 2, I, f. FIG. 3, E, a, b). More

liberal sporulation commonly takes place where nematodes have succumbed in colony-like groups; for in addition to the scattered conidia here likewise arising from prostrate hyphae (FIG. 6, *a*, *b*) a larger number of conidia are produced on aerial hyphae, often several hundred microns long, which seem given over entirely to

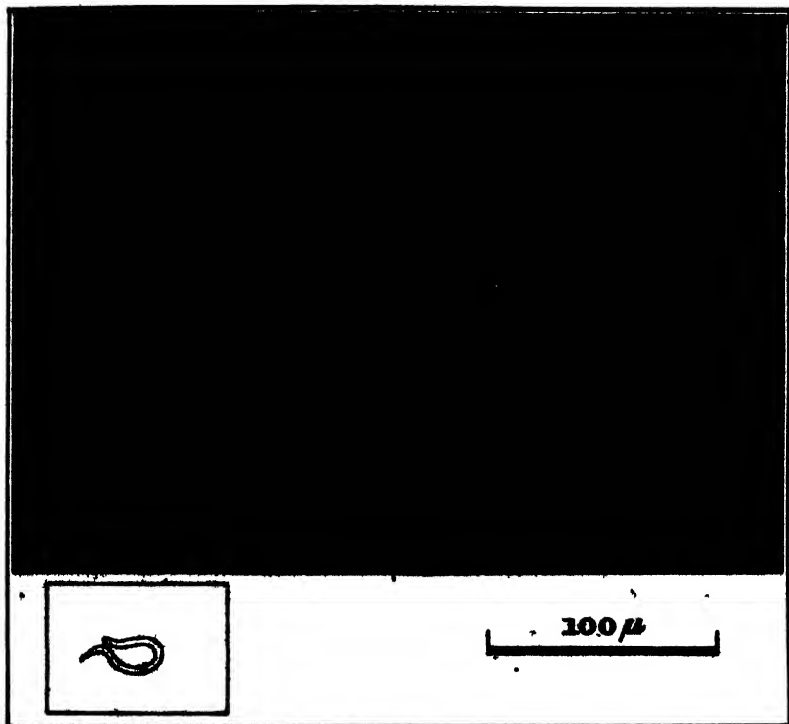


FIG. 5. *Nematoctonus haptocladus*.

asexual reproduction. These aerial hyphae (FIG. 4, *B*, *C*) are sometimes sparingly branched, and like the assimilative filaments are studded with clamp-connections at moderate intervals. In their earlier condition they ascend usually at a narrow angle with the horizontal. They bear their spores nearly vertically on sterigmata arising much more frequently between the clamps (FIG. 4, *B*, *a-c*; *C*, *a-g*; *D*) than directly from the clamps (FIG. 4, *E*). After their contents have largely been spent in production of conidia they decline to the substratum, much like the aerial conidiophorous hyphae of *Nematoctonus leiosporus* and *N. pachysporus*.

The sterigmata of the fungus rather closely resemble those of *Nematoctonus leiosporus* in length and distal width; but being evidently, in general, somewhat narrower at the base, they taper less markedly, and often, indeed, hardly seem to taper at all. The conidia borne on them (FIG. 2, *L*, *a-w*. FIG. 3, *F*, *a-r*) are conspicuously wider and shorter than those of *N. tylosporus* and *N.*



FIG. 6 *Nematoctonus haptocladus*

*leptosporus*; and they have a cylindrical or elongate-ellipsoidal shape differing markedly from the tapering shape distinctive of the spores of *N. leiosporus*, as well as from the plumper strobili-form shape characteristic of the conidia of *N. pachysporus*. With respect to volume they would seem equal or very nearly equal to the conidia of *N. pachysporus*, and perhaps are slightly larger than those of *N. leiosporus*; their greater width in comparison with the latter probably more than making up for their lesser length. From the strongly curved conidia of the congeneric predaceous Hawaiian species they differ not only in their lesser length and lesser width,

but more especially in that they are straight or at most slightly curved (FIG. 2, *L*, *p*. FIG. 3, *F*, *i*).

When a conidium falls on the moist surface of an agar culture, it gives rise at its distal end to a short, erect or ascending outgrowth which terminates in a glandular cell that soon becomes surrounded by a globule of adhesive secretion (FIG. 2, *M-Q*). The material required for production of the outgrowth is provided through evacuation of protoplasmic contents from the basal portion of the

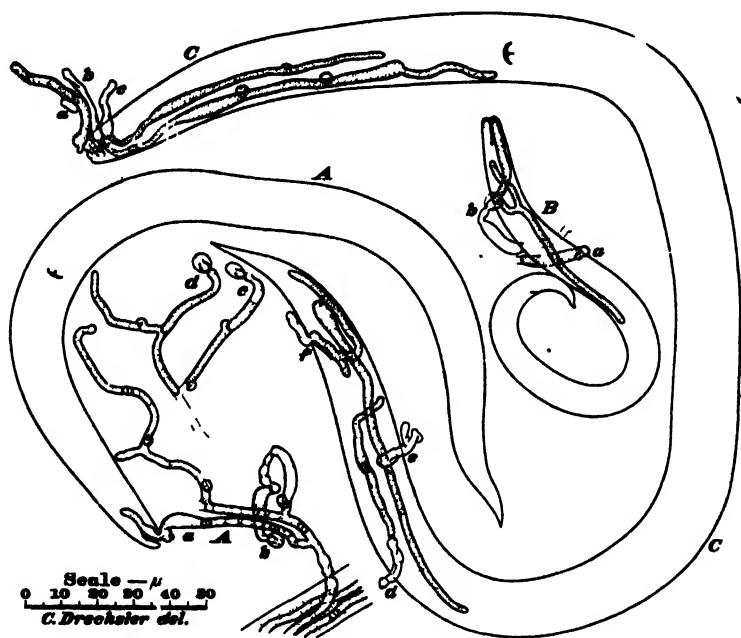


FIG. 7. *Nematoctonus haptocladus*.

spore. When this germinative development is concluded, a wall is laid down to delimit the living part from the emptied part (FIG. 2, *M-O*). In some instances, a retaining wall is laid down earlier, while evacuation is still in progress, so that in the end the spore comes to contain 2 transverse walls (FIG. 2, *P*, *Q*).

The adhesive outgrowth put forth by a disarticulated conidium corresponds, of course, to the erect or ascending terminations of predaceous branches; and operates quite similarly in effecting attachment to motile nematodes. Since, however, the disarticulated

spore lacks all anchorage below, and in itself is not bulky enough to impede seriously the locomotion of even a small eelworm, effective attachment of a nematode to the adhesive germ hypha results invariably in a parasitic rather than in a predaceous relationship. In fine, the conidia of the Colorado fungus are limited no less strictly to a parasitic mode of attack than the conidia of the 4 exclusively parasitic species of *Nematoctonus* previously described and named.

Infection of microscopic animals more or less directly by conidia of predaceous fungi is not unusual. Among the predaceous Zoopagaceae such infection has often been noted, for example, in the amoeba-destroying forms *Acaulopage marantica* Drechsl. (10: p. 144, fig. 6, B) *Zoöpage rhabdospora* Drechsl. (6: p. 375, fig. 4, C), and *Z. thannospira* Drechsl. (9: p. 143, fig. 2, F, G). As the elongate conidia of these species are being carried about by the actively moving animal to whose integument they have become affixed, they intrude haustoria much like conidia of the curiously ectoparasitic *Bdellospora helicoides* Drechsl. (4: p. 20-26), though often revealing an essentially predaceous characteristic in continuing simultaneously to germinate by putting forth a commonplace germ hypha (6: p. 375, fig. 4, C). Sometimes minute *Amoebae* much smaller than the animals habitually serving as prey become affixed to the conidia, as also to the mycelium, of members of the Zoopagaceae,—a relevant instance being given in a figure (5: p. 179, fig. 2, J) showing a filamentous conidium of *Acaulopage macrospora* Drechsl.,  $52\ \mu$  long and  $1.7\ \mu$  wide, from which haustoria have been intruded into 2 affixed pulvinate *Amoebae*, each about  $6\ \mu$  in its greatest dimension. Naturally the very feeble *Amoebae* are easily held captive by the larger adhering conidia, which therefore can be regarded as having established a predaceous relationship even though completely lacking hyphal anchorage. Likewise conidia of the predaceous hyphomycete *Pedilospora dactylopage* Drechsl., after directly burgeoning forth several digitiform adhesive processes (3: p. 396, fig. 1, S), have been observed capturing and destroying specimens of the small testaceous rhizopod *Geococcus vulgaris* Francé. The same rhizopod has been seen immobilized, invaded, and destroyed also by the large conidia

of the predaceous hyphomycete *Dactylella passalopaga* Drechsl. (7: p. 398, fig. 1, M).

Among the clampless predaceous hyphomycetes the manner and prevalence of attack by loose conidia varies greatly, owing in large part to the diversity of predaceous organs utilized in this group. When lying on the surface of a moist substratum the conidia of the several species employing adhesive networks sometimes germinate by giving rise exclusively to hyphal loops, or, again, sometimes produce several hyphal loops before the ordinary germ hyphae are long enough to insure good anchorage; several figures of such germination being included in Woronin's early illustrations of *Arthrobotrys oligospora* (18: pl. 6, figs. 12-14). Naturally when predaceous apparatus so weakly moored fastens on to an active nematode the whole array of loops is carried away together with the spore; the animal, nevertheless, being destined to succumb unless it should succeed in shedding the encumbering material rather promptly. At least two of the hyphomycetes that capture nematodes in constricting rings, namely *Arthrobotrys dactyloides* and *Dactylaria brochopaga*, are occasionally given to producing their remarkable predaceous organs directly on conidia (8: p. 483, fig. 6, K; p. 515, fig. 13, L-P) without putting forth any ordinary mycelial hyphae. A nematode caught in a predaceous ring of such origin continues to move about, carrying the spore clamped to its side, until disablement ushers in its death. When the conidium of *Dactylella asthenopaga* Drechsl. germinates, as it frequently does, by putting forth 1 or 2 predaceous organs (8: p. 497, fig. 9, N, a-c)—which in this species consist individually of a globose adhesive cell borne on a short sturdy stalk—it often adheres to specimens of *Bunonema*, and after being carried around a while, infects the sluggish animal (8: p. 497, fig. 9, O). Similar development has not been observed in *Dactylella leptospora* Drechsl., but should take place there also, since its conidia, when formed in pure culture, are frequently found bearing 1 or 2 globose cells (8: p. 505, fig. 11, N, a-k). Of all the clampless nematode-capturing hyphomycetes, *Dactylaria haptospora* Drechsl. (11: p. 456-461) undoubtedly displays the most consistently aggressive parasitic attack. Adaptation for such attack is clearly manifest in the curious morphology distinguishing the conidium of this



aberrant member of the predaceous series of hyphomycetes; the adhesive terminal cell, constantly present on the spore, providing ready attachment to an animal; and the slender shape of the spore being helpful in maintaining attachment by offering little resistance to movement through substratum, and consequently affording little opportunity for removal by the scraping or shearing action attending the animal's continued locomotion.

In whatever measure disarticulated conidia of the predaceous Zoopagaceae and predaceous clampless hyphomycetes may attack animals, it yet remains true that the conidia in all predaceous species referable to these two series are capable of putting forth a mycelium extensive enough, as a rule, to afford secure anchorage against the struggles of the animals habitually serving as prey; such germination being, indeed,—except possibly for the conidia of *Dactylaria haptospora*—their more usual or preferred manner of development. However, the conidia of the clamp-bearing Colorado fungus, like those of the 4 parasitic congeners previously named, have never been seen to put forth anything but the short aerial adhesive outgrowths so obviously designed to effect attachment to roving eelworms without directly halting their locomotion. Once an adhesive outgrowth has been produced, all further extensive development appears restricted to intrusion of assimilative filaments into a animal host. Among aquatic predaceous fungi similar limitation of asexual spores to attack of animals after the usual manner of parasites, would seem present at least in *Sommerstorffia spinosa*, where according to Arnaudow's (2) original account the zoospores after rounding up a second time regularly extend a short germ tube or infection tube, and subsequently infect living rotifers through the mouth. As the empty cysts of the zoospores were reported to measure only up to  $10\mu$  in diameter, production of germ hyphae robust enough for capture of rotifers would, of course, hardly be possible without considerable intake of nutrients. Dearth of protoplasmic content might be expected likewise to determine a parasitic manner of attack for the zoospores ascribed to *Zoophagus insidians* Somm., should these really belong to Sommerstorff's species or, for that matter, to any other aquatic rotifer-capturing phycomycete. With respect to their manner of attack it would presumably make little difference whether the

zoospores came into being through the *Pythium*-like development attributed to *Z. insidians* by Arnaudow (1) and Valkanov (17), or through the somewhat chytridial development described by Gicklhorn (16).

Although the clamp-bearing Colorado fungus was examined in some quantity, with the possibility of encountering basidial development being always kept in mind, it has so far been found to reproduce only by conidia. It is therefore described as a species of *Nematoctonus*; the specific name proposed for it, compounded of 2 words meaning "to fasten" and "branch," respectively, being intended to signalize its predaceous character.

***Nematoctonus haptocladus* sp. nov.**

Hyphae assumentes incoloratae, plus minusve ramosae, plerumque 1.8–3.0  $\mu$  crassae, rarius usque 4.5  $\mu$  latescentes, in modum Hymenomycetum septato-nodosae, intra vermiculum nematoideum viventum crescentes, post mortem animalis hyphas ex magna parte procumbentes aut ascendentes extra emittentes. Hyphae procumbentes septato-nodosae, plerumque 1.8–3.0  $\mu$  crassae, rarius usque 4.5  $\mu$  latescentes, ramos plerumque 20–75  $\mu$  longos expandentes qui prope apicem abrupte in aerum se flectunt, quoque ita columellam erectam vel ascendentem 2–8  $\mu$  altam porrigente; columella corpus bilobum medio constrictum 3.5–5.5  $\mu$  longum, 2–3  $\mu$  crassum ferente; corpore bilobo mox guttula glutinosa globosa vel ellipsoidea 4–6  $\mu$  longa 3.5–5.5  $\mu$  crassa circumdato, denique saepe ad vermiculum nematoideum inhaerente, animal capiente. Hyphae ascendentes incoloratae, parvulum ramosae, medio-criter septato-nodosae, saepe circa 500  $\mu$  longae, 1.5–2.5  $\mu$  crassae. Conidia incolorata, cylindrica vel elongato-ellipsoidea, recta vel leniter curvata, sursum rotundata, deorsum saepe parve attenuata, plerumque 11–18  $\mu$  longa, 3.3–4.5  $\mu$  crassa, erecta, in apice sterigmatis vulgo 2.5–4.5  $\mu$  longi, .8–1.2  $\mu$  crassi, raro ex hyphis procumbentibus crebrius ex hyphis ascendentibus oriunda; primo continua, protoplasmatis omnino repleta, post disjunctione saepe in parte inferiore evacuata et 1–2 septis instructa, denique ex apice hypham germinationis erectam 2–8  $\mu$  altam porrigentia quae corpus glutinosum fert.

Vermiculos nematoideos diversos praecipue *Panagrolaimum* capiens consumensque etiam eadem animalia soluta necans habitat in foliis plantarum (*Cucumeris sativi*, *Elacagni angustifoliae*, specierum *Syringae*, *Populi*, *Tamaricis*) putrescentibus prope Greeley, Colorado.

Assimilative hyphae colorless, more or less branched, mostly 1.8 to 3.0  $\mu$  in diameter, here and there widening to 4.5  $\mu$ , bearing clamp-connections, developing within living nematodes, after death of invaded animal putting forth prostrate and ascending external hyphae. Prostrate hyphae mostly 1.8 to 3.0  $\mu$  in diameter, here and there widening to 4.5  $\mu$ , provided with clamp-connections, ramifying at rather wide angles, the outspread branches, mostly

20 to 75  $\mu$  long, bending abruptly upward into the air to project as erect or ascending stalks 2 to 8  $\mu$  high; each stalk bearing a transversely constricted bilobate body .35 to 5.5  $\mu$  long and 2 to 3  $\mu$  wide; the bilobate body soon becoming surrounded by a globose or ellipsoidal droplet of glutinous substance, 4 to 6  $\mu$  long and 3.5 to 5.5  $\mu$  wide, then often adhering to a nematode and capturing it. Ascending hyphae colorless, meagerly branched, provided moderately with clamp-connections, often about 500  $\mu$  long and 1.5 to 2.5  $\mu$  wide. Conidia colorless, cylindrical or elongate-ellipsoidal, straight or slightly curved, broadly rounded at the tip, often tapering slightly toward the base, measuring mostly 11 to 18  $\mu$  in length and 3.3 to 4.5  $\mu$  in greatest width, borne erect on sterigmata, commonly 2.5 to 4.5  $\mu$  long and .8 to 1.2  $\mu$  wide, that arise sparingly from prostrate hyphae and in closer arrangement from ascending hyphae; the spores at first continuous and filled with protoplasm throughout, but after disarticulation regularly becoming evacuated proximally and partitioned proximally by 1 or 2 septa in extending from the apex an erect or ascending germ hypha, mostly 2 to 8  $\mu$  long, whereon an adhesive body is borne terminally.

Capturing and consuming various nematodes (especially *Panagrolaimus* sp.) and also destroying these animals in free condition, it occurs in decaying plant (*Cucumis sativus*, *Elaeagnus angustifolia*, *Syringa* sp., *Populus* sp., *Tamarix* sp.) leaves near Greeley, Colorado.

As was set forth in a recent paper (15: p. 3) elaboration of adhesive material in easily visible masses previous to encounter with prey has not been noted among the predaceous Zoopagaceae, and among the clampless predaceous hyphomycetes has been noted only in *Arthrobotrys entomopaga* Drechs., a species primarily adapted for capture of springtails, though occasionally also capturing nematodes (14). The statement then made to the effect that no fungus specially adapted for capture of eelworms secretes adhesive material in visible quantities beforehand (15: p. 3, lines 9-13), now requires modification limiting its application to the 2 main predaceous groups. Indeed, the anticipative secretory behavior wherein *Nematoclonus haptocladus* differs so markedly from the many nematode-capturing fungi taxonomically alien to it, is present likewise in the congeneric predaceous Hawaiian species which "utilizes erect hyphal processes bearing droplets of adhesive mucus at the tip" (12: p. 780, lines 33-35).

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## EXPLANATION OF FIGURES

FIG. 1. *Nematoctonus haptocladus*; adhesive bodies, about 34 in number, borne aloft on the upcurved tips of prostrate branches coming from the assimilative mycelium in a nematode, *A* (*Panagrolaimus* sp.), that has become nearly invisible owing to expropriation of contents. A second nematode, *B*, of the same species is shown attached to two of the adhesive bodies. Un-retouched photomicrograph,  $\times 300$ .

FIG. 2. *Nematoctonus haptocladus*; drawn to a uniform magnification with the aid of a camera lucida, from a moist preparation covered with a cover glass;  $\times 1000$  throughout. *A*, Branching hyphae extended under the surface of an agar culture from a specimen of *Panagrolaimus* sp. that had succumbed in a submerged position. *B*, Ramifying prostrate hyphal system with 5 predaceous branches bearing aloft the adhesive bodies *a-c*; the ramifying system having developed terminally on a hypha that came from a submerged eelworm to the surface of the culture. *C*, Terminal portion of a prostrate hypha with a single predaceous branch bearing aloft the adhesive body *a*. *D*, Portion of prostrate mycelium with a predaceous branch holding aloft the adhesive body *a*; one of the 3 clamp-connections present is shown empty of contents and only faintly visible. *E, F*, Predaceous branches, each bearing aloft an adhesive body, *a*; through evacuation of protoplasm, the living part of each branch has been reduced to a structure not differing much in shape, size, and function from a conidium that has put forth an adhesive germ hypha. *G*, Predaceous branch arising directly from an assimilative hypha, and terminating in the adhesive body *a*. *H*, Predaceous branch that has given rise successively to 3 adhesive bodies, *a, b, c*. *I*, Prostrate ramifying filament with 4 predaceous branches bearing aloft the 4 adhesive bodies *a-d*; a young conidium, *c*, is found arising from a clamp-connection, and 2 fully formed conidia, *f, g*, are shown attached, the latter arising from a clamp. *J*, Prostrate branch, in large part evacuated, terminating in an adhesive body, *a*, and bearing a conidium, *b*, on a sterigma arising from a clamp. *K*, Conidium borne on an empty sterigma arising from a clamp. *L*, Newly detached conidia, *a-u*, showing variations in size and shape. *M-O*, Disarticulated conidia, each of which has become evacuated proximally in putting forth a germ hypha with an adhesive body. *P, Q*, Detached conidia of similar development, but in which 2 septa were laid down during evacuation of the proximal part.

FIG. 3. *Nematoctonus haptocladus*; drawn to a uniform magnification with the aid of a camera lucida, from a moist preparation covered with a cover glass;  $\times 1000$  throughout. *A*, Portion of body of a nematode, referable to *Panagrolaimus* sp., that is occupied by assimilative mycelium; one of the assimilative filaments having put forth a prostrate ramifying system with 6 predaceous branches, whereon are borne 7 adhesive bodies, *a-g*. *B*, Prostrate ramifying system with 2 predaceous branches that after producing the adhesive bodies, *a* and *b*, respectively, have continued growth. *C*, Portion of prostrate ramifying system with a predaceous branch terminating in the adhesive body *a*. *D*, Somewhat extensive prostrate ramifying system, whose predaceous branches bear aloft the 10 adhesive bodies *a-j*; a conidium, *k*, is shown attached to a sterigma arising from a clamp-connection. *E*, Portion

of prostrate hyphal system showing 2 conidia, *a* and *b*, borne on empty sterigmata. *F*, Newly disarticulated conidia, *a-r*, showing variations in size and shape.

FIG. 4. *Nematoctonus haptocladus*; drawn to a uniform magnification with the aid of a camera lucida, from a moist preparation covered with a cover glass;  $\times 1000$  throughout. *A*, Posterior portion of a dead specimen of *Panagrolaimus* sp. occupied by assimilative mycelium of which terminal parts have become evacuated in supplying material for production of external hyphae; one of the 2 external hyphae shown has produced 2 adhesive bodies, *a* and *b*. *B*, Branched ascending hypha bearing 3 conidia, *a-c*; owing to lack of space the hypha is shown in parts whose proper continuity is indicated by means of the alphabetical sequence *n-s*; *n-q* being a proximal element that bears distally the branches *q-o* and *q-s*. *C*, Portion of specimen of *Panagrolaimus* sp. occupied by assimilative filaments, one of which has put forth an ascending branched hypha whereon are borne 6 mature conidia, *a-f*, and a very young, growing conidium, *g*; from lack of space the hypha is shown in parts whose proper continuity is indicated by the letters *x, y, z*. *D*, Portion of ascending filament showing a conidium in half-grown state. *E*, Portion of ascending filament showing a conidium almost full-grown but still continuous with the sterigma; the latter arising from a clamp-connection.

FIG. 5. *Nematoctonus haptocladus*; external growth made in 48 hours from the same individual eelworm shown in figure 1, *B*; approximately 30 predaceous branches, each with an adhesive body, being recognizable; a single conidium, also present, not being recognizable; unretouched photomicrograph,  $\times 300$ . After the photograph shown in figure 1 had been taken the culture was flooded with water for a few minutes, completely obliterating all the prostrate hyphae and adhesive bodies derived from nematode *A* of that figure; so that all the prostrate hyphae and adhesive bodies visible in the later photograph were necessarily produced during the intervening 2 days.

FIG. 6. *Nematoctonus haptocladus*; portion of colony-like group of nematodes mostly referable to *Panagrolaimus* sp.; showing, in addition to scattered predaceous branches, 2 conidia, *a* and *b*, arising from prostrate filaments; unretouched photomicrograph,  $\times 400$ .

FIG. 7. *Nematoctonus haptocladus*; drawn to a uniform magnification with the aid of a camera lucida, from a moist preparation covered with a cover glass;  $\times 500$  throughout. *A*, Prostrate ramifying hyphal system with 4 adhesive branches, *a-d*, on one of which, *a*, a specimen of *Panagrolaimus* sp. has been captured; slight movement of the animal from time to time showed it was still alive, though invaded by an assimilative hypha over 10  $\mu$  long. *B*, Small specimen of *Paraphelenchus pseudoparietinus* 48 hours after being captured by adhesion to 2 predaceous branches, *a* and *b*; both predaceous branches are still attached to the parent hypha, though their mycelial connection has become indiscernible owing to evacuation of intercalary hyphal parts. *C*, Specimen of *Panagrolaimus* sp. still capable of slight movement, but manifestly close to death, owing to hyphal invasion from 6 adhering predaceous branches, *a-f*; all the predaceous branches had been torn from their attachments to mycelium, and the animal was succumbing in a free condition.

# VARIABILITY OF *PYTHIUM ULTIMUM* FROM GUAYULE<sup>1</sup>

W. A. CAMPBELL AND BAILEY SLEETH

(WITH 2 FIGURES)

## INTRODUCTION

In the course of investigations on damping-off and root rot of guayule (*Parthenium argentatum* Gray) in the nurseries near Salinas, California, a *Pythium* was isolated frequently and consistently from diseased material. These isolates were similar in mat characters and growth rate. However, microscopic examination of the mats when grown on cornmeal agar revealed that a relatively large number of them failed to produce oogonia and antheridia upon which the identification of *Pythium* largely depends but produced only globose sporangia or sporangia-like bodies. Those that produced oogonia and antheridia were identified as *Pythium ultimum* Trow.<sup>2</sup> In the disposition of the non-oospore-producing isolates the writers (1) have indicated that they should also be considered as *P. ultimum* on the basis of their association with oospore-producing isolates.

The assignment of these non-oospore-producing isolates to *Pythium ultimum* raised certain taxonomic questions concerning variability within the species, particularly whether or not the existence of oospore- and non-oospore-producing forms could result from factors other than environmental. Therefore, the purpose of this paper is not only to report on the variability observed

<sup>1</sup> The interest and suggestions of the following individuals during the course of this study or in the preparation of the manuscript are gratefully acknowledged: H. N. Hansen, W. C. Snyder, John T. Middleton and Gladys Baker.

<sup>2</sup> The interpretation of Middleton (8) in respect to *Pythium ultimum* has been followed in this study. However, it is apparent from the variability observed in the structure of the antheridium and manner of attachment to the oogonium that Van Luijk's (12) contention that *P. ultimum* and *P. Debaryanum* belong to a single species in which considerable variation may be recognized deserves further investigation.

in spore formation (oospores and sporangia) in a number of *P. ultimum* isolates, growth rate in culture, pathogenicity to emerging guayule seedlings but also the results of successive hyphal-tip and single-spore subculturing of several isolates.

#### CLASSIFICATION OF ISOLATES

The majority of the isolates used in the present study were obtained over a period of two years by plating diseased guayule tissue on Sleeth's agar medium (10). One hundred and twenty-one isolates, which included 51 previously reported by the writers (1), were grown simultaneously in Petri dishes on Difco cornmeal agar in diffused light at room temperatures ranging from 20 to 28° C.<sup>3</sup> After 14 days the cultures were examined microscopically and classified on the basis of relative abundance of oospores and sporangia.<sup>4</sup>

The isolates varied greatly in the number of oospores and sporangia produced in culture and in the ratio between the two spore forms. Three classes or types of isolates were recognized and for convenience were designated as O OS and S (FIG. 1 and TABLE 3). The O type isolates produced mainly oospores and relatively few large globose terminal sporangia. However, small intercalary chlamydospores were commonly present as were disorganized oogonia. The OS type isolates produced oospores and a variable number of terminal and intercalary sporangia. The S type isolates produced only sporangia in culture. These varied from few to many and were characteristically terminal, globose, and up to 32  $\mu$  in diameter.

The OS type isolates were the most numerous comprising 71 of the 121 isolates examined; the S type was next with 47 isolates; and the O type isolates were relatively few with only 3 so classified.

<sup>3</sup> All results unless otherwise specified herein reported on spore production are based upon observations made on Difco cornmeal agar, following the procedure given above.

<sup>4</sup> Although the structures analogous to sporangia in *Pythium ultimum* do not produce zoospores but germinate with a germ tube, and have been termed chlamydospores or conidia, the term sporangia will be used rather than chlamydospores or conidia to designate all large globose non-oospore-producing structures in order to avoid confusion in type designations with those established by Hansen (3) in his studies on the dual phenomenon in imperfect fungi.



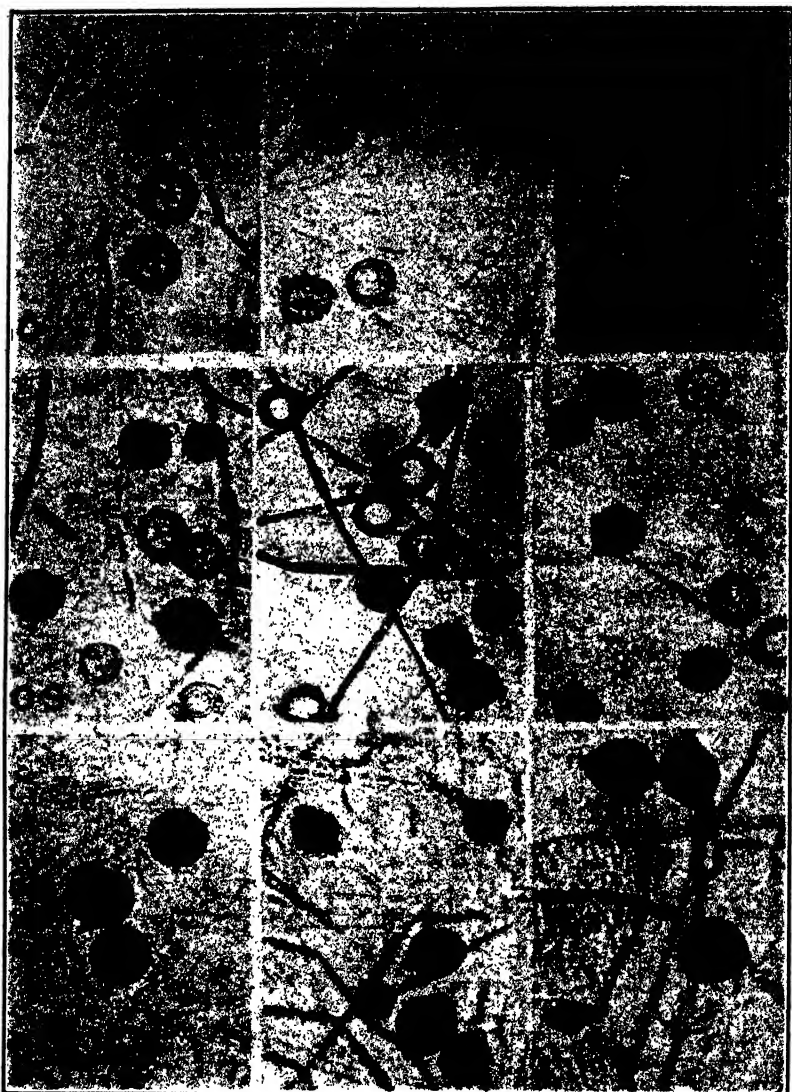


FIG. 1. Types of *Pythium ultimum* isolates based upon relative numbers of oospores and sporangia produced on cornmeal agar.

*Top*—Type O isolates in which oospores or disorganized oogonia are predominant. Sporangia may occur but these are relatively few in proportion to oospores.

*Center*—Type OS isolates in which both oospores and sporangia are prevalent. The number of oospores in proportion to sporangia may be quite variable in this class.

*Bottom*—Type S isolates in which only sporangia develop.

## HYPHAL TIP SUBCULTURES OF 25 ORIGINAL ISOLATES

The original *Pythium* isolates were obtained from small bits of diseased tissue and the possibility existed that some of them were mixtures of two or more types. In order to eliminate the possibility of mixed cultures, single hyphal-tip transfers were made from 25 of the 121 *Pythium* isolates which exhibited the widest range of variation in spore formation; three were O type isolates; 15 OS and 7 S (TABLE 1).

TABLE 1

DATA ON *Pythium ultimum* ISOLATES USED IN VARIABILITY STUDY  
All isolates were obtained from guayule in the vicinity of Salinas, California.

Isolate	Culture type	Material from which obtained	Location	Date isolated
C111	O	Pink root rot lesion	Nursery	9/ 2/44
912	O	Seedling root rot	Field seeding	7/24/44
945	O	Pink root rot lesion	Nursery	9/12/44
B17	OS	Seedling root rot	Nursery	6/12/43
T52 <sup>1</sup>	OS	Pink root rot lesion	Field seeding	8/12/43
C104 <sup>1</sup>	OS	Pink root rot lesion	Nursery	9/ 1/44
515	OS	Seedling root rot	Field seeding	7/ 6/43
690	OS	Seedling root rot	Nursery	5/10/44
700	OS	Seedling root rot	Nursery	5/12/44
736	OS	Seedling root rot	Nursery	5/16/44
740	OS	Seedling root rot	Nursery	5/17/44
800	OS	Root rot	Nursery	6/ 2/44
917	OS	Seedling root rot	Field seeding	7/24/44
968	OS	Pink root rot lesion	Field seeding	9/21/44
980	OS	Pink root rot lesion	Field seeding	9/21/44
1010	OS	Seedling root rot in moisture experiment	Greenhouse	12/23/44
1041	OS	Damped-off seedlings	Greenhouse	12/26/44
1046	OS	Damped-off seedlings	Greenhouse	12/26/44
B25	S	Seedling root rot	Nursery	6/ 8/43
B48a	S	Seedling root rot	Nursery	6/ 9/43
50a	S	Seedling root rot	Nursery	6/ 9/43
T53	S	Seedling root rot	Field seeding	8/12/43
648	S	Seedling root rot	Nursery	4/28/44
1042	S	Damped-off seedling	Greenhouse	12/26/44
1050	S	Damped-off seedling	Greenhouse	12/26/44

<sup>1</sup> Identification verified by John T. Middleton.

Twenty hyphal-tip subcultures were made of each of the 25 isolates and examined for the presence of oospores and sporangia after 14 days on cornmeal agar. The hyphal-tip subcultures from all of the O and S type isolates were similar to the parent cultures. Four of the OS type isolates yielded subcultures of both O and S

or OS and S types indicating the possibility that they had been carried in the laboratory as mixed cultures (TABLE 2).

TABLE 2

HYPHAL-TIP SUB-ISOLATES OBTAINED FROM 4 *Pythium ultimum* ISOLATES WHICH WERE MIXED OR UNSTABLE AS TO TYPE

Isolate	Original isolate	Hyphal-tip cultures		
		Type O	Type OS	Type S
	Type	Number	Number	Number
C104	OS	9	0	11
736	OS	1	0	19
800	OS	0	11	9
980	OS	0	9	10

#### VARIATION IN SPORE NUMBERS

In order to determine the relative abundance of oospores and sporangia and to verify the classification of the 25 selections (TABLE 1), 26 hyphal-tip subcultures which included one or several from most of the 25 selections were grown in duplicate on cornmeal agar. The plates were incubated in diffused light, at room temperature for 17 days. Spore counts were made with the high power of the microscope (10X ocular and 4 mm. objective). Forty observations were made, 20 on each plate, by two observers and the average number of oospores and sporangia computed (TABLE 3). Only fully developed oospores were counted; immature or disorganized oogonia were disregarded. Small intercalary or terminal chlamydospores were not counted and sporangia were considered as the large terminal bodies ranging in size from approximately 20 to 32  $\mu$ .

The data (TABLE 3) on relative spore numbers show considerable variation in the numbers of spores of each kind produced by the different isolates. The line of separation between the different types is likewise not sharp and distinct and there are isolates that fall on the borderline between the O and OS types and between OS and S types. This is to be expected and does not necessarily invalidate the convenience afforded by classification of the isolates of *Pythium ultimum* into types.

Hartley (5) in dealing with a *Pythium* species which he designated as *Pythium Debaryanum* observed a similar condition in respect to variability in spore formation. He reported strains with few oospores and many chlamydospores (sporangia), those in which a reverse relationship existed and also intimated that certain strains produced few if any oospores.

TABLE 3

RELATIVE ABUNDANCE OF OOSPORES AND SPORANGIA FOR DIFFERENT ISOLATES OF *Pythium ultimum* WHEN GROWN ON CORNMEAL AGAR AT ROOM TEMPERATURE FOR 17 DAYS

Culture	Type	Average per field <sup>1</sup>		Culture	Type	Average per field	
		Oospores	Sporangia			Oospores	Sporangia
945-14	O	2.9	.01	690-1	OS	3.3	4.2
912-1	O	2.5	.2	980-1	OS	2.4	4.2
C111-1	O	2.8	.3	700-1	OS	3.1	6.3
736-14	O	1.1	.9	980-14	OS	0.1	8.0
B17-1	OS	3.6	1.1	648-1	S	0	2.0
800-1	OS	5.1	1.2	B25-1	S	0	2.1
515-1	OS	4.8	1.5	C104-9	S	0	2.5
917-1	OS	2.9	1.6	1050-1	S	0	2.5
1010-1	OS	5.0	2.0	T53-1	S	0	2.6
740-1	OS	4.2	2.0	1042-2	S	0	3.2
1046-1	OS	2.3	3.0	50a-1	S	0	4.0
968-1	OS	6.0	3.0	B48a-1	S	0	4.2
T52-1	OS	3.5	3.6	980-17	S	0	7.0

<sup>1</sup> Average per high power field (10X ocular  $\times$  4 mm. objective) of 40 observations on 2 plates of each isolate.

#### SPORE FORMATION ON SPECIAL MEDIA

Various workers with *Pythium* have experienced difficulty in inducing certain isolates to produce oospores on standard culture media. For example, Rands and Dopp (9) found that many but not all isolates of *P. arrhenomanes* which failed to produce oospores on ordinary culture media did so if humic extract was added. Johann (6) reported that grated carrot agar was helpful in securing oospores of several species which did not readily produce them on ordinary agar media. Following the suggestions of these and other workers the *Pythium* isolates that failed to produce oospores on cornmeal agar were grown on water agar, cornmeal agar plus an extract of guayule shrub, cornmeal agar plus soil extract, and

agar made from freshly grated carrots. None of these special agars stimulated the formation of oospores in the S type cultures.

Cornmeal agar appears to be the most satisfactory culture medium for the production of oospores in *Pythium ultimum*. Ordinarily maximum spore production is achieved at room temperature in 14 days and little or no increase in spore numbers could be noted on further aging. Thickness of agar influences sporangia production and usually more sporangia are produced on thick agar layers than on thin. The presence or absence of oospores in *P. ultimum* appears to be a fairly stable quality which is not readily affected by the quantity of culture medium.

#### GROWTH AT CONSTANT TEMPERATURES

*Pythium ultimum* isolates of the three different types appeared to have the same growth rate when grown at room temperatures ranging from 20° to 28° C. In order to ascertain if this were also true at higher and lower temperatures, 29 hyphal-tip subcultures which included 5 type O, 13 type OS and 11 type S were grown on cornmeal agar at constant temperatures of 10, 15, 20, 25, 30, 35 and 40° C.

Inoculations were made from 2- to 4-day-old cultures, growing on cornmeal agar, using a uniform circular piece of inoculum 4 mm. in diameter. The inoculum was placed mycelium side down at the edge of the agar in the Petri plate so that the mycelium would have approximately 8 cm. of agar for growth before reaching the opposite side of the dish. The plates were held at room temperature from 4 to 5 hours until discernible growth had started, then inverted and incubated for 48 hours at the desired temperature in incubators which maintained these temperatures within 1° C.

The growth rates of all 29 hyphal-tip subcultures were remarkably similar regardless of type and agreed closely with the temperature growth data for *Pythium ultimum* presented by Middleton (8). There appeared to be no noticeable difference between the rate or kind of growth of the S type cultures and those of O and OS types. The optimum temperature for mycelial growth of *P. ultimum* as determined by these isolates falls between 25 and 30° C.

## PATHOGENICITY

Pathogenicity tests were made on emerging guayule seedlings with the 26 single hyphal-tip subcultures listed in table 3. The different subcultures were grown on a wheat bran mixture (wheat bran 400 grams, dextrose 20 grams, distilled water 600 ml.) which had been sterilized by autoclaving for 60 minutes at 15 lbs. pressure. After 10 days of growth at room temperature in which time the mycelium had permeated the 40 grams of bran mixture in a 250 ml. Erlenmeyer flask, the contents of 2 flasks of the same isolate were uniformly distributed over the surface of pasteurized soil in eight 6-inch clay pots. The layer of inoculum was then covered with  $\frac{1}{2}$  inch of soil upon which 50 guayule seeds were sown and covered with  $\frac{1}{4}$  inch of pasteurized sand. The eight pots inoculated with a single isolate of *P. ultimum* were randomized in 8 blocks on benches in the greenhouse. The pots were watered and cared for so as to secure maximum emergence in the checks. All of the 26 isolates were tested twice for pathogenicity, the second test being made approximately one month after the first.

Seedling emergence counts were made daily from the day the first emergence occurred, to 15 days after sowing. Usually the peak of emergence had occurred by the 10th day. The seedling emergence in the checks, which included pots with and without sterilized bran inoculum, ranged from 90 to 95 per cent of the germinable seed sown. The average emergence for any one isolate in the fungal inoculated pots never exceeded 2 per cent of the germinable seed sown.

All of the isolates were pathogenic to guayule germination and emergence and of comparable virulence. Thus there was no indication that virulence of the isolates tested was associated with the presence or absence of oospores.

VARIATION IN HYPHAL TIP AND SINGLE SPORE SUBCULTURES OF  
SELECTED ISOLATES

The occurrence of the O, OS and S types which were isolated from diseased guayule seedlings was highly suggestive of the "dual phenomenon" of Hansen (3) which is common in the imperfect fungi. In order to determine whether or not the differentiation

into oospore, oospore-sporangia, and sporangial types of *Pythium ultimum* isolates could be explained on the basis of the dual phenomenon, extensive hyphal-tip and single-spore subcultures were made of selected hyphal-tip isolates. In obtaining single-spore cultures it was found that the oospores, except rarely, failed to germinate on solid agar medium and that it was necessary to use the asexual spores for this purpose. The latter germinated readily in dilution plates on Sleeth's medium or water agar within 3 to 4 hours at room temperature. Their relatively large size, from 20 to 32  $\mu$  in diameter, made it a simple operation to lift the germinating spores from the agar disk under the binocular dissecting microscope. Hyphal-tip subcultures were made 24 hours after inoculating on Sleeth's medium. This medium was more suitable for this purpose than water or cornmeal agars because the hyphae tended to separate better and it was easier to remove the individual hyphal tips. A hyphal tip was cut with a sharp flattened needle and removed from its position to an area where no hyphae had penetrated. After checking with the binocular microscope to see that only one tip was included in the agar piece, it was transferred to a Petri dish or test tube.

Six isolates were selected for hyphal-tip or single-spore subculturing. Two, 1041 and 1046, were chosen because they produced approximately equal numbers of oospores and sporangia in culture and had been pure as to type when isolated; two, 1042 and 1050, were chosen because they produced only sporangia in culture and had been isolated as pure types; and two, C104 and 980, were selected because they had been isolated originally as mixed types or had separated into types O and S for the former and OS and S for the latter on subculturing (TABLE 2).

Three generations of single-spore cultures of 1041 and 1046 failed to produce a single subculture which differed noticeably from the OS type isolates from which they were derived. The number of single-spore cultures in the three generations for 1041 was 63, 44 and 50 respectively, and for 1046, 85, 68 and 24.

One generation of single-spore subcultures of 1042 and 1050 failed to produce a single one with oospores. Seventy-eight single-spore cultures were made from 1042 and 112 from 1050. No further single-spore subcultures were made of these isolates as the

large number involved in the first generation was considered sufficient to detect any variation toward oospore production that might exist.

Isolate C104, obtained in September 1944, had been carried in the laboratory for approximately 6 months at the time hyphal-tip subcultures were made. One mass mycelial transfer of the original isolate was stored in the refrigerator and another was left at room temperature in the laboratory. In preparation for single hyphal-tip subculturing mycelial transfers were made from the two cultures of C104 which were stored under different conditions. The transfer from the culture stored in the refrigerator produced both oospores and sporangia; the one from the culture kept at room temperature produced only sporangia. Since this was the first time that a change had been noted in type of spore production, 3 successive mass mycelial transfers were made of the S type culture and carefully examined for oospores. None was found. The OS type culture of C104 segregated into 9 type O and 11 type S on hyphal-tip subculturing. Further hyphal-tip subculturing of a type O subculture obtained by the first hyphal-tip series gave all type O cultures; a type S subculture likewise gave all S types. The S type culture which originated from a mass mycelial transfer was also hyphal tipped yielding 3 type O subcultures and 17 type S.

The original OS type isolate 980 segregated into 9 OS type subcultures and 10 S type on hyphal tipping (TABLE 2). The 9 OS type subcultures were different from those obtained from any other *Pythium ultimum* isolate in that they varied considerably in the number of oospores produced. Two OS type subcultures, selections 1 and 14, were saved for further hyphal tipping as was one S type, selection 17. Oospores were fairly common in selection 1 (TABLE 3), but extremely rare in selection 14, and entirely lacking in selection 17.

Seventeen hyphal-tip transfers of selection 1 segregated into 3 type OS and 14 type S (FIG. 2). Eight OS type and 17 S type subcultures were obtained from single-spore transfers.

Twenty hyphal-tip transfers of selection 14 segregated into 1 type O (selection 13), 2 OS type (selections 11 and 12) and 17



S type. Twenty-five single-spore subcultures of selection 14 gave 6 OS type and 19 S type.

A third hyphal-tip generation using the type O subculture selection 13, as the base, gave 16 or all O type cultures. A third hyphal tipping of the type OS subculture selection 11, gave 14 OS

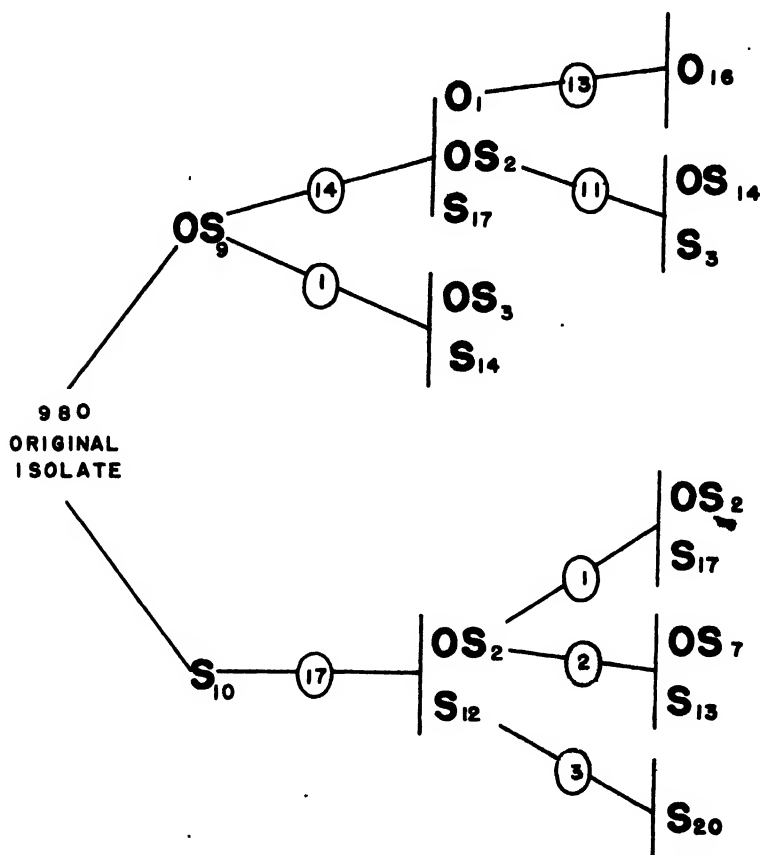


FIG. 2. Culture Types Obtained by 3 Successive Hyphal Tippings of Isolate 980.

type and 3 S type cultures. These 14 OS type subcultures exhibited considerable variation in respect to the number of oospores produced. In 3 of the subcultures only one or two oospores could be found, in 4 a few oospores were present so that one or more could be found in each low power field, and in 7 many oospores were produced and correspondingly fewer sporangia.

The second generation hyphal tipping of the type S subculture designated as selection 17 gave 2 OS type and 12 S type isolates (FIG. 2). Selection 1 from the above generation produced very few oospores, in fact, only one could be located on thorough examination on the plate. Selection 2 of the same generation, also an OS type culture, produced a number of oospores. These 2 selections were hyphal tipped for the third generation. Selection 1 gave 2 cultures that were OS type and 17 that were S type. Selection 2, which produced more oospores, gave 7 type OS and 13 type S cultures. A third generation hyphal tipping of selection 3 in which no oospores were found gave 20 type S subcultures.

There was some indication that sectoring leading to variation in spore formation occurred in culture even though no apparent change in mycelial growth could be detected. In making hyphal-tip transfers from a rapidly growing 24-hour-old culture, 40 to 50 mm. in diameter, individual hyphal tips were picked off successively in a clockwise manner and serially numbered. In several cases 2 to 4 hyphal-tip subcultures were obtained from branched hyphae of a single hyphal strand and on two different occasions 2 or more successive hyphal-tip subcultures were found to be of a different type from the others. For example, the 3 subcultures that produced oospores in selection 14 (FIG. 2) developed from hyphal tips 11, 12 and 13. Likewise the two OS type subcultures from selection 17 developed from hyphal tips 1 and 2.

#### DISCUSSION

The investigation of variability of *Pythium ultimum* was the outgrowth of what disposition should be made of isolates which in all essentials, except the lack of oospores, were comparable to ordinary isolates of *P. ultimum*. In these isolates only the asexual spore stage, sporangia (or chlamydospores), was present. According to various keys for the determination of *Pythium* species, isolates which fail to produce oospores are difficult to classify (7, 8). Similar conditions have been reported by various investigators (5, 9, 11) and have been disposed of by considering such non-conforming isolates to be of the same species as that which was most frequently isolated from the suspect and which produced oospores. A similar position was taken by the writers in an

earlier paper (1). This disposition of the non-oospore-producing isolates of *Pythium ultimum* was justified by finding that hyphal-tip subcultures of the OS type gave rise to the S type by means of successive hyphal-tip or single-spore transfers.

The present study has demonstrated that the species *Pythium ultimum* is composed of a number of strains which differ in their capacity to produce either oospores or sporangia or both. Furthermore, the evidence presented shows that the relative numbers of oospores and sporangia produced by a strain were fairly constant. That is, a strain which produced many oospores and few sporangia, one that produced few oospores and numerous sporangia, or one that produced only sporangia, would likely continue to do so for an indefinite number of hyphal-tip or single-spore transfers.

The stability of many *Pythium ultimum* strains and the difficulty of securing divergent lines from hyphal-tip or single-spore transfers may be explained by the homothallic nature of the fungus (8, 13) and the failure of the mycelium to anastomose. No anastomosis of hyphae was observed in any of the *P. ultimum* cultures examined. These two conditions tend to fix the characteristic of a strain and reduce to a minimum the chances for variation. Even though numerous strains of *P. ultimum* are found in a given locality it is believed to be the result of strain stability rather than a tendency to readily give rise to different strains.

The stability of single-spore or single hyphal-tip isolates in culture and their seeming reluctance to "break-down" into divergent types is assumed to be evidence that the various strains are fairly stable in nature. On the other hand it is reasonable to expect certain strains to be less stable than others, and a very small number to be exceedingly unstable. The behavior of the single hyphal-tip and single-spore isolates obtained in culture substantiates this assumption. Although, most of the isolates in successive single-spore or hyphal-tip transfers were similar to the parent culture, some few and particularly those from isolate 980, an oospore-sporangia type, gave rise to the parent type and both the S and O types.

To account for variation within a fungus species many suggestions and possible explanations may be found in the literature. Tompkins et al. (11) found that certain isolates of *P. ultimum*

from pumpkin and watermelon failed to produce oospores in culture. They stated "It seems probable that the failure of certain isolates to develop oospores is the result of failure to form antheridia. Since there is no evidence that a heterothallic condition occurs in the species it is suggested the monosexuality exhibited by these strains may be genetic in nature." Hansen (3) stated that variability in certain fungi "is not due to mutations (genetic instability) in pure cultures but rather to the fact that many fungi as they exist in nature, although operating as definite entities, are composed of two distinct elements or individuals." He applied the term "dual phenomenon" to this condition and indicated that it is "due to a condition of heterocaryosis." Contrary to this view Chilton (2) in a report on a number of variants of *Colletotrichum destructivum* stated that the "variants were not due to a heterocaryotic condition of the mycelium," but that "the evidence indicates they are genetic entities differing from the cultures from which they arose." He therefore suggested that they are mutants. Hansen (4) in further discussions on variability stated that both heterocaryosis (dual phenomenon) and genetic instability (mutation) operate in creating variability in fungi. In a homothallic fungus, such as *P. ultimum*, in which the sexual phase is seemingly of minor importance in propagating the fungus, it is suggested that variation may develop as the result of mutation (gene mutation or somatic segregation) which gives rise to a heterocaryotic condition. Somatic mutation would likely occur as readily in a homocaryotic individual as in a heterocaryotic one and it might well be that this sort of mutation occurs more frequently than is suspected.

#### SUMMARY

One hundred and twenty-one isolates of *Pythium ultimum* Trow from diseased guayule (*Parthenium argentatum* Gray) seedlings were classified into 3 types on the basis of relative abundance of oospores and sporangia (chlamydospores) when grown on Difco cornmeal agar. Three of the isolates which produced mainly oospores were classified as type O; 71 which produced oospores and few or many sporangia were classified as type OS; and 47 which produced only sporangia were classified as type S.

Twenty hyphal-tip subcultures were taken from each of 23 selected isolates. The subcultures from three O type, 11 OS type and 7 S type were similar to the parent cultures; those from 4 OS type isolates segregated into two that gave type O and type S subcultures and 2 that gave type OS and type S indicating that these four isolates were mixed cultures or were unstable as to type.

In an effort to induce isolates of the S type (non-oospore formers) to produce oospores they were grown on cornmeal agar, water agar, cornmeal agar plus an extract of guayule shrub, cornmeal agar plus an extract from well-decayed leaf mold, cornmeal agar plus soil extract, and agar made from freshly grated carrots. None of these media stimulated the formation of oospores in the S type isolates.

Five O type, 13 OS type and 11 S type hyphal-tip subcultures of 25 isolates were found to have very similar rates of growth on cornmeal agar at each of the following constant temperatures: 10°, 15°, 20°, 25°, 30°, 35° and 40° C. The growth rate at these temperatures was comparable to that reported (8) for *Pythium ultimum*. The optimum temperature for mycelial growth was found to be between 25° and 30° C.

Twenty-six hyphal-tip subcultures which included four O type, 13 OS type and 9 S type were tested for pathogenicity on emerging guayule seedlings in the greenhouse. All of the different types were found to be pathogenic and of comparable virulence in causing preemergence loss to guayule seedlings.

In general most hyphal-tip or single-spore subcultures of *Pythium ultimum* isolates were stable as to type. However, one isolate, 980, readily gave rise to other types. Successive hyphal-tip transfers of a hyphal-tip subculture of 980 of the OS type gave rise to both the O and S types as well as the parent type. Three generations of single-spore (sporangium) subcultures from two isolates of the OS type were all OS type similar to the parent. Likewise one single-spore generation of two S type isolates were all of the S type.

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# GUIGNARDIA RHODORAE, THE PERFECT STAGE OF PHYLLOSTICTA MAXIMA ON RHODODENDRON<sup>1</sup>

B. H. DAVIS<sup>2</sup>

(WITH 2 FIGURES)

During the last three years frequent collections of *Rhododendron* leaves from several New Jersey plantings have been examined for leaf-spotting fungi. Examinations early in the work revealed the common occurrence of two pycnidial forms both of which possess characteristics in common with those of the genus *Phyllosticta*. One of these has large, granular, ovoid to globose-elliptical spores, whereas the spores of the other are small and dumbbell-shaped. It became apparent very soon that these were often associated in the same or in similar lesions. Later a perithecial stage was found intermingled with both *Phyllosticta* forms. The association of these forms suggested that they were the pycnidial, spermagonial, and perithecial stages of the same fungus. Proof of this and the identity of these three stages are reported in this paper.

## LEAF SYMPTOMS, HOSTS, AND CULTURAL CHARACTERISTICS

The lesions in which any one or all of the above-mentioned types of fruit bodies occur are usually marginal but may occur anywhere on the leaf blade. Marginal lesions range from 3 mm. to 4 cm. in length and from 2 mm. to 2 cm. in width. Often the coalescing of spots forms a continuous necrotic lesion along most of the margin.

<sup>1</sup> Journal Series paper of the N. J. Agricultural Experiment Station, Rutgers University, Department of Plant Pathology.

<sup>2</sup> The writer is indebted to Dr. Anna E. Jenkins, Mycology and Disease Survey, U. S. Department of Agriculture, for help in connection with examination of specimens and checking of literature, and to Dr. C. L. Durham, Cornell University, for help in connection with the Latin names and endings. He is also indebted to Dr. John A. Stevenson, Mycology and Disease Survey, U. S. Department of Agriculture, and to Dr. F. J. Seaver, of the New York Botanical Garden, for their kindness in making specimens available for study.

Lesions in the center of the leaf are circular and range from 2 mm to 2 cm in diameter. The spots are reddish brown in contrast to the light brown to tan color of lesions resulting from sunburning or winter injury. The margins of the spots are only slightly darker than the central portions (fig. 1, A)

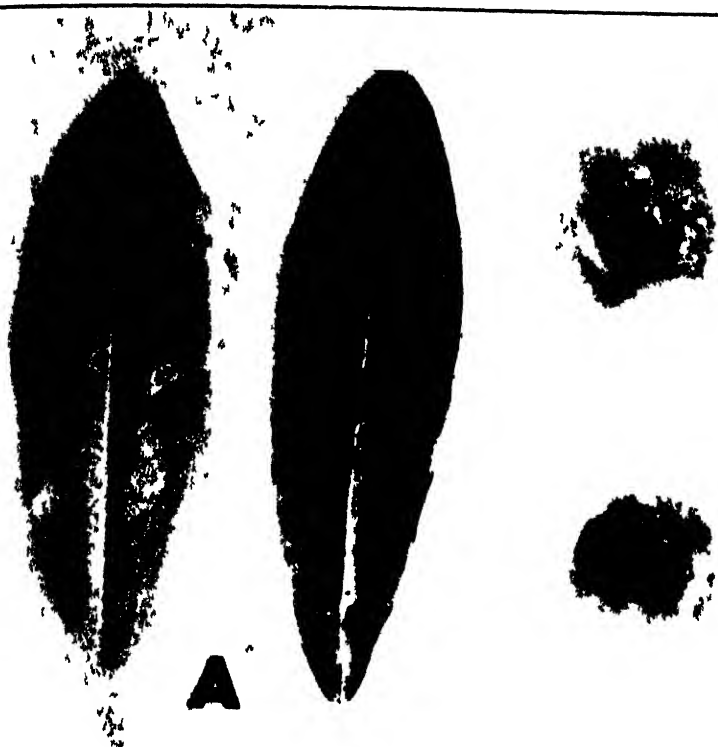


FIG. 1 *Guignardia Rhodora*. A, leaf lesions containing perithecia, pycnidia and spermagonia  $\frac{2}{3}$  natural size. B, cultures derived from ascospores on potato-dextrose agar, 2 weeks old, natural size.

One or more of the various stages of the fungus have been found on *Rhododendron maximum* L., *R. carolinianum* Rehd., *R. catawbiense* Michx., and some of the *catawbiense* hybrids. Weiss (13) records the fungus on *R. nudiflorum* Torr.

Cultures of the fungus have been derived from tissue plantings, pycnosporos, and ascospores. The individual hyphae appear hya-



line, but the colonies, when cultured on potato-dextrose agar, are slightly yellowish. The fungus is slow-growing. After a period of 2 to 3 weeks colonies which usually contain mature pycnidia are 2 to 3 cm. in diameter (FIG. 1, B). Spermatogonia and perithecia have not been found in agar cultures.

#### PYCNIDIAL STAGE

The pycnidial stage of the fungus appears as epiphyllous (rarely hypophyllous), black, spherical, slightly prominent bodies. Although they may be found sparsely scattered over the entire lesion, they are sometimes more numerous near the margins. They range in size from 125 to 200  $\mu$  in diameter, usually 140 to 150  $\mu$ . The spores, which are produced on slender stalks, are ovoid to globose-elliptical (sometimes pyriform), hyaline, granular, and range in size from  $11.5$  to  $17.5 \times 7.5$  to  $9.5 \mu$ , usually  $13.0$ – $14.5 \times 8.5 \mu$  (fresh material).

The pycnidial stage has characteristics in common with *Phyllosticta maxima* described by Ellis and Everhart (3) in 1888. Their description follows:

*Phyllosticta maxima* Ellis & Ev.—on leaves of *Rhododendron maximum*, Bedford, Mass., July '83. Coll. Rev. Thos. Morong. Com. A. Commons.

Spots large, reddish-brown with a darker margin, mostly terminal or lateral, (3–5 cm.). Perithecia scattered, epiphyllous minute ( $\frac{1}{2}$  mm.), their sub-acute apices slightly prominent. Sporules globose-elliptical, hyaline, granular,  $10$ – $12 \times 6$ – $8 \mu$  on rather slender pedicels about equal in length to the diameter of the sporule. The fruit is much like that of *P. sphaeropsoides* Ellis & Ev. and the habit that of *P. terminalis* Ellis & Martin.

In 1892 Ellis and Everhart (4) reported *P. Rhododendri* West. on *Rhododendron catawbiense* based on a Newfield, New Jersey, collection of April 20, 1891. The spores are described as narrowly and acutely elliptical and  $15$ – $20 \times 6$ – $7 \mu$ . Later in 1900 in their publication, North American Phyllostictas (5), they describe the spores as narrow-elliptical and  $10$ – $20 \times 6$ – $7 \mu$ . Number 2765 of North American Fungi, collected at Newfield, New Jersey, in April 1891 is given as a specimen and the name *P. maxima* recorded as a synonym.

In the original description of *P. Rhododendri* as given by Saccardo (9), Westendrop describes the spores as cylindrical-ovate (no measurements given). The narrow-elliptical spores ( $15-20 \times 6-7 \mu$ ) in Ellis and Everhart's description of *P. Rhododendri* and specimen No. 2765 of North American Flora (FIG. 2, E) compare favorably with the original description. However the granular globose-elliptical spores,  $10-12 \times 6-8 \mu$ , in the original description for *P. maxima*, which they later record as a synonym, do not agree with either their or Westendrop's description of *P. Rhododendri*.

The writer has been unable to locate an Ellis and Everhart specimen which bears data corresponding to those given with the original description of *P. maxima*. Dr. W. L. White reports that the Herbarium of Cryptogamic Botany at Harvard does not contain the type specimen, and the writer does not find a packet bearing the exact data in the Herbarium of the New York Botanical Garden. However there exists in the latter a specimen labelled *P. maxima* which was collected by Thos. Morong and sent to Ellis and Everhart by A. Commons. The packet is marked "Ex-Herb. A. Commons No. 851." This specimen was collected at Medford, Massachusetts, and bears the date July-Aug. 1879, whereas the type material was collected at Bedford, Massachusetts, in July 1883. Although this cannot be considered the type, it may be considered an authentic specimen determined by Ellis. Spores from this collection are granular, globose-elliptical (FIG. 2, A) and  $10-14 \times 7-8.7 \mu$ , which is slightly larger than that given by Ellis and Everhart ( $10-12 \times 6-8 \mu$ ). Only a few spores were found. Our New Jersey specimens have larger spores,  $11.5-17.5 \times 7.5-9.5 \mu$ , when collected. However, the size of spores in dried specimens is slightly smaller. Thus the writer's material agrees well with the Commons collection in the size, shape, and granular nature of the spore.

The Herbarium of the New York Botanical Garden contains two other specimens from the Ellis Herbarium both of which are labelled *P. Rhododendri* West. One of these is specifically the same as the writer's material whereas the other contains elliptical spores which are longer and narrower,  $15-20 \times 6-7 \mu$ . The latter is specifically the same as specimen No. 2765 of North American

Flora (FIG. 2, E) labelled *P. Rhododendri* in the herbaria of the New York Botanical Garden, the New Jersey College of Agriculture, and the mycological collections of the Division of Mycology and Disease Survey. Another Ellis and Everhart specimen de-

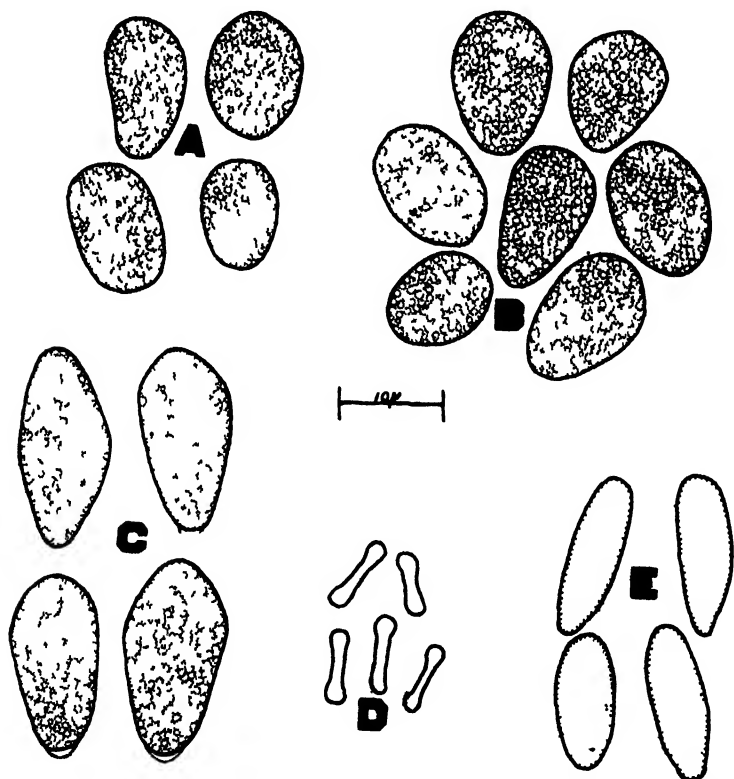


FIG. 2 A, *Phyllosticta maxima* Spores from Ellis and Everhart's specimen B-D, pycnospores, ascospores, and spermatia of *Guignardia Rhodorae* from New Jersey collections. E, spores from North American Fungi No 2765, *P. Rhododendri* Drawn with aid of camera lucida

posited in the last named herbarium labelled *P. Rhododendri* is specifically the same as No. 2765 of North American Flora.

Thus two Ellis specimens which are specifically the same, one labelled *P. maxima* and the other *P. Rhododendri*, have granular, globose-elliptical spores. The characteristics of this fungus agree with the original description of *P. maxima*. This is especially true since the original description states that the "fruit is much

like that of *P. sphaeropsoidea* Ellis & Ev. . . ." In addition to No. 2765 of North American Fungi, two other specimens from the Ellis Herbarium labelled *P. Rhododendri* have narrow-elliptical, non-granular spores. These agree with Ellis and Everhart's description of this fungus.

The writer considers *P. Rhododendri*, as represented by No. 2765 of North American Fungi (FIG. 2, E), and *P. maxima* (FIG. 2, A) as distinct species and feels that Ellis and Everhart were not justified in reducing their name, *P. maxima*, to a synonym of *P. Rhododendri* West. It is to be noted that Seaver (11) also questions this synonymy.

Although the original spelling of the specific name of Ellis and Everhart's species is "*maxima*," Saccardo (10) changed it to "*Maximi*." It seems probable that Ellis and Everhart had in mind naming their *Phyllosticta* for the specific name of its host, *Rhododendron maximum*. If this is true Saccardo is correct in that "*Maximi*" means a *Phyllosticta* "of the giant" with the noun, *Rhododendron*, implied. Such a change is permissible under the International Code of Nomenclature. However, it is possible that Ellis and Everhart had in mind "a giant *Phyllosticta*" which would thus call for the spelling "*maxima*." Although the former interpretation is more likely, the latter is possible and the writer feels, therefore, that it is preferable to retain the original spelling.

#### SPERMAGONIAL STAGE

The spermatogonia usually develop later than the pycnidia. However, mature spermatogonia may be found in lesions containing both young and old pycnidia as well as perithecia. They are small spherical black bodies ranging in size from 60 to 125  $\mu$  in diameter. The spermatia which are produced on slender stalks are long and narrow,  $5.0-8.5 \times 1-1.5 \mu$ . Their knob-like swollen ends, which become less prominent after drying, give them the appearance of a dumbbell (FIG. 2, D). Under moist conditions they exude from the spermatogonia and form a small amber-colored drop at the ostiolum. All attempts to germinate these spores have failed.

Several species of *Phyllosticta* with small spores have been described on *Rhododendron*. Of these the characteristics of *Phyllosticta Saccardo*i Thüm. compare favorably with those of the

spermagonia described above. The writer has examined No. 1786 of De Thuemen's Mycotheca Universalis labelled *P. Saccardo*i at the New York Botanical Garden and the mycological collections of the Division of Mycology and Disease Survey and has found that the fruit bodies are similar. Unfortunately no spermatia were found. Dr. R. P. White reports by letter that he and Dr. C. L. Shear found the dumbbell-shaped spores in the type material of *P. Saccardo*i and that they are identical with the spermatia in question. Specimens in Dr. White's collections identified after this date and identical with the writer's fungus are labelled *P. Saccardo*i Thüm. The spermagonial stage is considered to be specifically the same as *P. Saccardo*i Thüm.

The name *P. Rhododendri* Sacc. (not Westendrop) is given by Saccardo (Syll. Fung. 3: page 23) as a synonym of *P. Saccardo*i. Several other small-spored phyllostictas have been reported on *Rhododendron* some of which may also be identical with *P. Saccardo*i, but the writer has not had an opportunity to check authentic material. One of these is *P. Rhodorae* (Cooke) Tassi, which Cooke (2) suggests in his original description may be the spermagonial stage of *Sphaerella* (*Laestadia*) *Rhodorae* Cooke. Since the latter is shown by the writer to be connected with *P. Saccardo*i, *P. Rhodorae* may be a synonym. This fungus has been reported from Oregon by Zeller (15).

#### PERITHECIAL STAGE

The association of a perithecial stage in the same lesions with the pycnidial and spermagonial stages and the occasional occurrence of spermatia and pycnospores in the same pycnidia strongly suggested that all three of these forms were merely stages of the same fungus. Pieces of leaves containing perithecia were placed in drops of water on the underside of a lid of a petri dish containing potato dextrose agar. After the ascospores were shot, pieces of agar containing several spores were transferred to other petri dishes with agar. The spores germinated in a few hours, producing germ tubes most of which died after growing 2 or 3 mm. directly down into the agar. However a few continued to grow and pure cultures were obtained.

Plantings of mycelium derived from ascospores were made on sterilized strips of *Rhododendron* leaves in test tubes with moist cotton in the bottom. Examinations of these after a period of a month showed the presence of perithecia and also the pycnidia and spermagonia described previously. Perithecia were not obtained in all cultures made. This may have been due either to the lack of production or to the improper timing of the examinations. The same type of culturing was repeated using cultures derived from pycnospores, with the same results. Furthermore it has been noted that one of Ellis and Everhart's specimens of *P. maxima* also contained immature perithecia with characteristics similar to those described above. Thus the pycnidia, spermagonia, and perithecia are merely stages of the same fungus.

The perithecia are epiphyllous, globose to depressed-globose and are embedded in the leaf tissue with only the ostium extending through the epidermis. Those which develop in moist chambers are partially erumpent. The wall of the perithecium, which is thicker near the ostium, is  $11.5\text{--}19.5\ \mu$  in thickness and is composed of brown pseudoparenchymatous cells. Perithecia range from  $125\text{ to }200\ \mu$  in diameter. The asci are  $80\text{--}120 \times 12.5\text{--}16\ \mu$ , fasciculate, 8-spored, clavate, rounded at their tips and possess short stalks. The wall is thickened at the apex. The asci extend to almost twice their original length at the time the spores are shot. No paraphyses have been found. The spores are sub-biseriate, granular, one-celled, broadly elliptical (sometimes sub-rhomboidal) in shape, and measure  $15\text{--}19 \times 7.3\text{--}10.2\ \mu$  (FIG. 2, C). Many of the ascospores possess a detectable basal and a very faint apical pseudo-cell.

The characteristics of the ascigerous stage are identical with those of the genus *Guignardia* which is considered by Miller and Thompson (6) to be restricted to forms with uniloculate stromata, with no beak, fasciculate asci, no paraphyses and one-celled ascospores. Specimens were sent to Miller and Thompson, who found the fungus typical of the genus *Guignardia*.

The specific characteristics agree closely with *Sphaerella* (*Lae-stadia*) *Rhodora* described by Cooke (1) on *Rhododendron* in England. His description follows:

*Sphaerella (Laestadia) Rhodora* Cooke

Epiphyllous, perithecia gregarious, seated upon large irregular ferruginous spots, immersed in the parenchyma, subglobose, black, piercing the cuticle with the punctiform ostiola. Asci clavate, without paraphyses (.80–1.20  $\times$  .16). Sporidia elliptical, hyaline, continuous (perhaps .015  $\times$  .007 mm. but too immature to measure with certainty).

On living leaves of *Rhododendron*. Kew.

This can scarcely be the *Laestadia Rhododendri*, De-Not. of Saccardo's Sylloge.

It will be noted that the measurements of the immature spores reported in Cooke's description are the lower limits of those given for New Jersey specimens. However the size of immature spores from our collection more nearly approaches that given by Cooke. The perithecial stage is considered specifically the same as *Sphaerella (Laestadia) Rhodora* Cooke, and the new combination is proposed.

**Guignardia Rhodora** (Cooke) comb. nov.

Syn. *Sphaerella (Laestadia) Rhodora* Cooke

*Laestadia Rhodora* (Cooke) Berl. & Vogl.

*Phyllosticta maxima* Ellis & Ev.

*Phyllosticta Saccardoi* Thüm.

*Phyllosticta Rhododendri* Sacc. (not West.)

Our New Jersey specimens of *G. Rhodora* are specifically the same as the following deposited in the Herbarium of the Division of Mycology and Disease Survey of the Bureau of Plant Industry:

*Laestadia Rhodora* (Cooke) Berl. & Vogl.

Brooklyn Bot. Garden, N. Y.; July 25, 1916.

Col. G. M. Reed; Det. A. E. J. and F. W. P.

*Laestadia Rhododendri* De-Not.

Arlington Farms, Va.; May 29, 1915.

Col. J. T. Rogers; Det. G. R. Lyman.

*Laestadia Rhododendri* De-Not.

Germantown Nurseries, Pa.; June 4, 1892.

Col. Thos. Meeham; com. Dr. Rex.

*Laestadia Rhododendri* (De-Not.). Sacc. mentioned above and originally described as *Sphaerella Rhododendri* De-Not. has now

been placed in the genus *Physalospora* by Rehm (8). The spores are described as  $35-48 \times 8-12 \mu$ .

The structures of *G. Rhodora* on *Rhododendron* are similar to but in general larger than those of *G. Vaccinii* Shear described on *Vaccinium* and reported on *Kalmia latifolia* from New York by Welch (14). The spermagonia and pycnidia of *G. Rhodora* also appear larger than corresponding structures of a similar fungus collected by Dr. R. P. White and the writer on *Kalmia* in New Jersey. No pycnidia of the *Kalmia* fungus have been found by the writer. Although this fungus may be identical with *G. Rhodora*, the size of its structures appears to agree more nearly with those of *G. Vaccinii*.

It is to be noted that the pycnidia, spermagonia, and perithecia of *G. Rhodora* are similar to but larger than those of *Guignardia Bidwellii* (Ellis) Viala & Ravaz. The ascospore of *G. Bidwellii* has a pseudo-cell at one end which is described by Reddick (7) as an inflated hyaline vesicle. He agrees with Prilleaux and quotes the latter in saying "that they bear at their extremity a little mucilaginous material, inflated and transparent, which probably aids in fixing them to the leaf where they may germinate." The same type of structure is visible on the basal end of most of the ascospores of the *Rhododendron* fungus, but much less prominent than in *G. Bidwellii*. A similar structure is sometimes faintly detectable at the apical end. Examinations of immature perithecia which have been crushed under a cover glass show that young ascospores forced from the ascus have cytoplasmic contents of the ascus adhering to them, suggesting that the mucilaginous material may be derived from adhering cytoplasmic contents.

In 1924, T. A. Tengwall (12) reported *Uromyces Rhododendri* Tengwall as the perfect stage of *Phyllosticta maxima*. He states that isolations from leaves received at the Phytopathological Laboratory at Baarn yielded two fungi, *Pestalotzia guepini* and *Phyllosticta rhododendricola* Brun., which produced dark colored mycelium on cherry agar. Inoculation experiments carried out with the latter gave positive results and a few of the infected leaves which fell from the inoculated plants were placed on filter paper in a petri dish. Later, these were sectioned and the presence of *P. rhododendricola* was demonstrated. The author states that two



other species were also found on these fallen leaves, *P. maxima*, which was sometimes found in the same fruit body with *P. rhododendricola*, and a pyrenomycete which he described as new under the name *Venturia Rhododendri*. On the basis of the above association, *V. Rhododendri* was considered the perfect stage of *P. maxima* and *P. rhododendricola*. Tengwall also considers the names *P. berolinensis* P. Henn. and *P. rhododendri-flavi* Bub. & Kab. as synonyms.

The perfect stage which Tengwall figures and describes is clearly a species of *Venturia* and distinctly different from that of the writer's. It is assumed that the conidial fungus which he determined as *P. maxima* and considers the imperfect stage of *V. Rhododendri*, is specifically different from that which the writer found to be identical with Ellis & Everhart's specimens of *P. maxima*.

#### SUMMARY

In this study an ascigerous stage, originally described as *Sphaerella* (*Laestadia*) *Rhodorae* Cooke, is connected by means of pure culture methods with its pycnidial stage *P. maxima* Ellis & Ev. and its spermagonial stage *P. Saccardoi* Thüm. The characteristics of the perithecial stage are considered to be those of the genus *Guignardia* and the name *G. Rhodorae* (Cooke) comb. nov. is proposed. Synonyms are listed.

*P. maxima* is considered a distinct species and not synonymous with *P. Rhododendri* West. as reported by Ellis and Everhart. It is also considered distinct from the fungus determined by Tengwall as *P. maxima* and reported by him as the imperfect stage of *Venturia Rhododendri* Teng.

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# ADDITIONS TO THE FUNGI IMPERFECTI ON GRASSES IN THE UNITED STATES <sup>1</sup>

RODERICK SPRAGUE <sup>2</sup>

(WITH 2 FIGURES)

The fungi listed in this article have all been collected by the writer in the western United States except the first three species.

## ***Septoria digitalivora* sp. nov.**

Maculis ellipticis, v. diffusis, brunneis, tarde centro subalbidis; pycnidiis conspersis, sparsis, brunneis, ostiolatis, erumpentibus, subglobosis v. subellipsoideis, 110–128  $\mu$ , parenchymaticis; pycnosporulis clavato-filiformibus, apicis acutis, basis subobtusis, 3–7 septatis, 45–95  $\times$  3.6–5.6  $\mu$ .

Hab. in foliis vivis *Digitariae sanguinalis* (L.) Scop., West Virginia.

Spots elliptical, finally diffuse, brown or fuscous, later isabelline in the centers; pycnidia scattered, few to several to a lesion, seldom gregarious or two or three may be grouped, brown parenchymatous, erumpent, subglobose to subellipsoidal, 110–128  $\mu$ , ostiole small; pycnospores clavate-filiform, apex acuminate, base subobtuse, 3- to 7- often 5- to 7-septate, contents somewhat coarse, hyaline, but with yellow or chlorotic inclusions, 45–95  $\times$  3.6–5.6  $\mu$ , but mature spores are mostly 70–95  $\times$  3.6–4.5  $\mu$ . Mean spore size 84  $\times$  4  $\mu$ , ratio of length to width 21 to 1.

In living leaves of *Digitaria sanguinalis* (L.) Scop., A. D. Hopkins, Mineral Wells, W. Va. (Without date, 1943.)

The spores of this species (FIG. 1, a) are much like those of *Phacoseptoria Urvilleana* (Speg.) Sprague (12) except that they

<sup>1</sup> Coöperative investigation between the Divisions of Cereal Crops and Diseases, Forage Crops and Diseases, Dry Land Agriculture, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration; Division of Nurseries, Soil Conservation Service, U. S. Department of Agriculture, and the North Dakota Agricultural Experiment Station.

<sup>2</sup> Pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering.

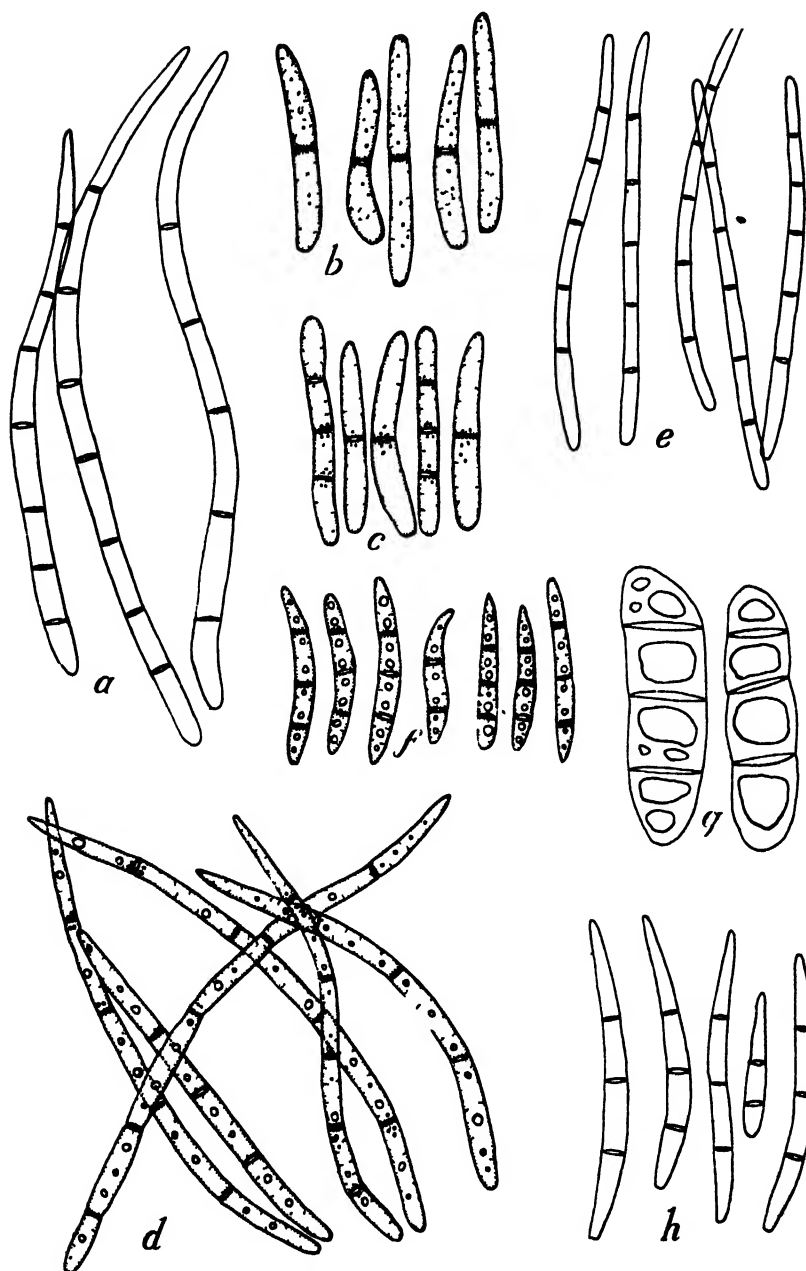


FIG. 1. Spores of *Septoria* and *Stagnospora*.

are somewhat narrower and lack the brown color. They also have the general shape of those of *Septoria Andropogonis* var. *Sorghastri* Greene & Sprague (6, 14, 16) but they are considerably coarser than those of this fungus on *Sorghastrum*. *S. digitarivora* does not appear to be the same as any species previously described. The mature spores are sometimes as much as 24 times as long as wide and, therefore, are not related to *Stagonospora arenaria* Sacc. (13). It is surprising that this fungus has not been found previously, but the leaf spots of the eastern United States grasses have not been thoroughly studied. Seymour (8) reports *S. graminum* Desm. on *Digitaria*, but *S. graminum* (17) is very different from our specimen and it is doubted if the citation in Seymour's text refers to a fungus that is at all like the one collected by A. D. Hopkins. The type, which bears the number B. P. I. 80,869, now filed in the Mycological Collections of the Bureau of Plant Industry at Beltsville, Md., was forwarded through the courtesy of J. G. Leach and K. W. Kreitlow.

#### SEPTORIA ARECHAVALETAE AND *S. TANDILENSIS* ON PANICUM

A fungus referable to *S. Arechavaletae* Wint. was collected on *Panicum capillare* L. in Virginia by David Fairchild, Aug. 16, 1889. The scattered pycnidia contain quantities of exceedingly long, filiform, obscurely septate, hyaline spores  $50-115 \times 1.0-1.5 \mu$ . The type description by Winter reported spores  $60-80 \times 1.5-2 \mu$  (21). Comparable species are *S. laxa* Speg. (10) with filiform spores  $50-60 \times 1 \mu$  and *S. tandilensis* Speg. (9) with spores  $40-60 \times 1-1.5 \mu$ . The first species described was *S. Arechavaletae* but it is suspected that all three species may be the same. The Virginia material is referred to *S. Arechavaletae*. Unfortunately the type of this species is not available and a study of the pycnidial characters of the group indicates that *S. tandilensis* may also occur in the United States and may warrant recognition as a distinct species. *S. Arechavaletae* has sparse, subgregarious, totally immersed, globose pycnidia ( $100 \mu$ ) while *S. tandilensis* Speg. (9) was described as having somewhat more gregarious, black cupulate, collapsed pycnidia. Most of the eastern collections seen have the typical black pycnidia of *S. tandilensis* but with somewhat too long spores as based on Spegazzini's description. The United States

material has spores as much as  $80-90\mu$  long. Material has been seen from Virginia (Diehl), Wisconsin (J. J. Davis and Greene) and along the coast to Florida on various species of *Panicum*. Most of these stray collections, long undetermined, from the Atlantic coastal region are devoid of pycnospores but the pycnidia contain prosenchymatous material. No maturing perithecia however have been found. Any of this material is readily identified by the grouped black pycnidia, which are somewhat cupulate-collapsed in the winter condition.

Until the types can be compared it is better to call the common fungus with the black pycnidia *S. tandilensis* and refer Fairchild's specimen to the earlier described *S. Arechavaletae*.

*S. sigmoides* Ellis & Ev. (4) from Iowa is not a species of *Septoria* but is near *Hendersonia crastophila* Sacc. *Septoria Donacis* Pass. var. *Panici* Ellis & Barth., *nomen nudum*, has falcate spores and is a narrow-spored form of *Selenophoma Donacis* (Pass.) Sprague & A. G. Johnson. *Septoria Urvilleana* Speg. on *Panicum Urvilleanum* Kunth. from the Argentine is elsewhere placed in *Phaeoseptoria* (12). Seymour lists *S. graminum* J. J. Davis, non Desm. on *Panicum depauperatum* Muhl. (8). Davis (3) in 1942 listed *S. tandilensis* on this host, stating that it is perhaps not distinct from *S. graminum*. This material is what the writer agrees is *S. tandilensis*.

#### SEPTORIA MELICAE PASS.

*S. Melicae* was found on *Melica scabrosa* Trin. in field plots at Mandan, N. Dak. It produced white elliptical spots with brown borders on above-ground parts of maturing plants. The pycnidia were yellow-brown, subglobose,  $80-120\mu$  diameter and contained bacillar spores  $22-38 \times 2.8-3.8\mu$  (FIG. 1, b). Some of the spores were mature and 3-septate but most of them were 1-septate partly developed summer spores. This fungus is very similar to a number of other fungi including *Septoria Avenae* Frank and *Stagonospora Arrhenatheri* A. L. Sm. & Ramsb. The latter is, we now believe, a synonym of *S. Avenae* as *S. Melicae* also may well prove to be.

Our specimen appears to be the first collection of this fungus on *Melica* in North America although Seymour (8) lists *S. Avenae*

on *Schizachne purpurascens* (Torr.) Swallen, which is a species of grass that was for many years listed under *Melica*.

#### SEPTORIA SECALIS VAR. STIPAE SPRAGUE

The type of this variety has 3-septate spores,  $37-54 \times 2.6-3.1 \mu$  (15), but much of the summer material in North Dakota has 1- to 3-septate spores,  $22-40 \times 2.6-3.7 \mu$ . These are from 8 to 10 times as long as broad, and represent a *Stagonospora*-like phase of the fungus. Morphologically they appear to be the same fungus as *S. Secalis* var. *Stipae* and are considered only a warm-season phase of this variety. Pycnosporos from a collection on *Stipa Williamsii* Scribn. from the plots at Mandan, N. Dak. (B. P. I. 80,870), are illustrated (FIG. 1, c). In this phase it is similar to the *S. Avenae* complex. Microspores,  $5-10 \times 0.5-0.7 \mu$ , were found.

In addition, the writer has found a species of *Septoria* on *Stipa comata* Trin. & Rupr. at Mandan, N. Dak., which he refers to *S. Andropogonis* f. *sporobolicola* Sprague. The obclavulate spores are  $40-73 \times 2.4-3.4 \mu$  (FIG. 1, d). This fungus was very common at Mandan in 1944. It produces a dark brown blotch, which is confusable with *Pseudomonas coronafaciens* var. *atropurpureum* (Reddy & Godkin) Stapp. It probably is more common than available collections indicate. Material on *S. comata* was obtained east of Crane, Mont., June 20, 1945 (B. P. I. 81,121).

#### SEPTORIA SPARTINAE (TREL.) SPRAGUE

Saprophytic material similar to *S. Spartinae* occurs on dead culms of *Beckmannia syzigachne* (Steud.) Fern. in North Dakota at Buffalo Lake and near Carrington, usually associated with other fungi. In the Buffalo Lake material the pycnidia were small.  $60-90 \mu$ , black, deep-seated, somewhat longer than broad and contained hyaline (or faintly yellow in mass) 1- to 2-septate spores  $35-44 \times 2.9-3.3 \mu$ . The spores are blunt at the base and taper to a sharp apex, and they are stiffly curved. They are slightly less cylindrical than those of *S. Spartinae* but are otherwise sufficiently close to permit assignment to that species. *Beckmannia* and *Spartina* have similar marshy habitats and both belong to tribe Chlorideae of the Gramineae. The only other *Septoria* found on related grasses is *Septoria Cynodontis* Fuckel, which has filiform

spores  $50-65 \times 1.5-2 \mu$  and may therefore be eliminated from consideration.

#### SEPTORIA QUINQUESEPTATA SPRAGUE

This species, recently described (14), is herein illustrated (FIG. 1, *e*). Another collection on *Sphenopholis obtusata* from Devil's Lake, N. Dak., has spores close to *S. Andropogonis* J. J. Davis (FIG. 1, *h*) and is assigned to that species. *S. quinqueseptata* is related to the *S. Andropogonis* complex, but the material in the type appears to indicate that it has definitely narrower spores.

#### STAGONOSPORA FOLIICOLA (BRES.) BUB.

Syn.: *Stagonospora vexata* Sacc. var. *foliicola* Bres.

*St. vexata* var. *Baldingeriae* Sacc.

We have seen several collections of a *Stagonospora* on *Phalaris arundinacea* L. from the United States (Iowa, Ky., Minn., N. Dak., Wis.) with spores  $27-45 \times 2.7-4.1 \mu$ . These were referred with some hesitation to *Stagonospora arcuaria* Sacc. (13). Recently the writer finally obtained mature spores of the *Stagonospora* on *Phalaris* from abundant material in the plots at Mandan, N. Dak. The spores were  $38-67 \times 4.6-6 \mu$ , stoutly obclavulate, with a tapering, finally blunt base and an acute apex, 3- to 8-septate, sometimes, but less often not, constricted at the septa (FIG. 2, *a*). This fungus is *Stagonospora foliicola* (Bres.) Bub. (1), which is common in Europe. It produces an elliptical, brown to vinaceous spot, which later becomes diffused as a wine colored blotch on the leaves. John A. Stevenson sent material of J. Smarod's Fungi Latvici Exsiccati No. 441, which had spores  $47-56 \times 4.5-5.8 \mu$  and they were mostly 7-septate. He also sent *St. vexata* var. *Baldingeriae* from Vestergren's Micromycetes Rariores Selecti No. 1443 from Mércy-sur-Seine, France, which fungus is only a saprophytic phase of *St. foliicola*.

*St. foliicola* is readily obtained in pure culture on potato dextrose agar. It forms a slow-growing, white, cottony growth with pink color in the substratum. It is much slower growing than *St. arenaria*. It has, to date, remained sterile in pure culture on *Melilotus* culms.



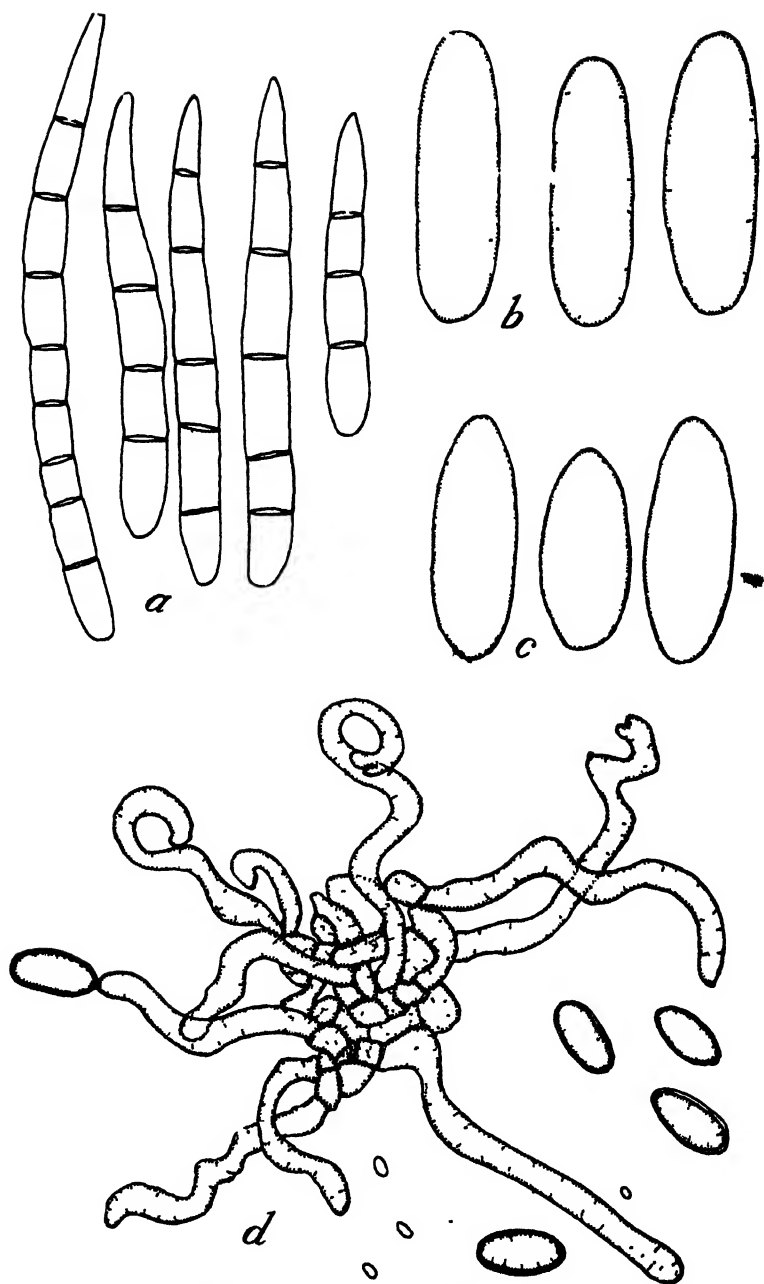


FIG. 2. Spores of *Stagnospora*, *Macrophoma* and *Oculularia*.

Abundant material of *St. foliicola* from Mandan has been sent to the Division of Mycology and Disease Survey, Bureau of Plant Industry, Beltsville, Md., for distribution. *St. foliicola* also occurs on *Phalaris californica* Hook. & Arn. in Marin County, Calif. (W. B. Cooke).

There appear to be some differences in the susceptibility of clones and of strains of *Phalaris arundinacea* to this fungus in the plots at Mandan. The plots are on sandy upland ground. The fungus usually does not appear in abundance until August but by early September it occurs on almost 100 per cent of the leaves of susceptible plants.

#### STAGONOSPORA SIMPLICIOR SACC. & BERL.

Saprophytic material was abundant on *Calamovilfa longifolia* (Hook.) Scribn. in mid-September, 1943, at Mandan, N. Dak., following light frosts (B. P. I. 80,884). The symptoms were vague, stramineous or gray areas, and the pycnidia were scattered to grouped, black, globose and mostly 110–140  $\mu$  in diameter. The blunt pycnophores bore hyaline to faintly yellow, cylindrical or slightly bent, obtuse, 3-septate spores, which were slightly to scarcely constricted at the septa (FIG. 1.g). The spore contents were coarse, sometimes consisting mainly of one huge cell inclusion. The spores were  $28\text{--}35 \times 8\text{--}9 \mu$  as compared with  $32\text{--}38 \times 8\text{--}9 \mu$  for the type on *Phragmites communis* in France.

*St. simplicior* f. *Andropogonis* Sacc. was described from North Dakota material (Brenckle). H. C. Greene sent material to us of a fungus on *Sorghastrum nutans* (L.) Nash from Madison, Wis., which he determined as this variety (6). It appears to be parasitic in elliptical spots on living leaves. *St. simplicior* is likely to prove rather widespread on coarse grasses in the prairie regions, but except for the Wisconsin material has not been shown to be associated with living host parts.

#### STAGONOSPORA AGROSTIDIS FORMA ANGUSTA f. NOV.

Maculis fuscis v. stramineis v. nullis, pycnidiis globosis, aureis, parenchymaticis, ostiolatis, 120–280  $\mu$ ; pycnosporulis fusiformibus, subacutis, rectis v. curvulis, basis subobtusis v. subtruncatis, non constrictis, 3-septatis, hyalinis, conspicue guttulatis (4–8),  $15\text{--}27 \times 2.2\text{--}3.2 \mu$  (medio  $22.3 \times 3 \mu$ ).

Hab. in foliis et vaginis *Stipae viridulae*, 22 miles n. of Beach, N. Dak., July 10, 1940 (B. P. I. 80,976).

We also have material on *Elymus canadensis* L. collected at Foster, Warren Co., Ohio, by Wm. Bridge Cooke (14,538), which has spores virtually identical with the fusoid, cylindrical to rarely subfalcate ones of this species. This material, however, is associated with *Phyllachora graminis* (Pers.) Fuckel and is distinct from the *Stipa* material. Other collections than the type from North Dakota are associated with rust pustules or in some cases with summer material of *Septoria Secalis* var. *Stipae*. It is distinguished from the 1-septate phase of the latter (FIG. 1, c) by the somewhat curved, fusiform or fusoid spores (FIG. 1, f) which are nearly all smaller than the smallest of the bacillar spores of *S. Secalis* var. *Stipae*. In old material the spores of the *Stagonospora* take on a yellow tinge. They are, however, far lighter in color than their nearest affinity in *Hendersonia*, *H. simplex* Schroet.

There are a number of other fungi described that show similarity in some characters with *St. Agrostidis* f. *angusta* but which differ in others. *St. insularis* Speg. on *Agrostis magellanica* has cylindrical to subclavate spores  $18-24 \times 3 \mu$ , but the pycnidia are small,  $80-90 \mu$ , lenticular and fuliginous, too different to indicate relationship. *St. Agrostidis* Syd. (18) on *Agrostis vulgaris* is closer to *St. Agrostidis* f. *angusta* as the pycnidia are  $180-250 \mu$  in diameter, and the 3-septate spores are fusoid, curved to subfalcate with acute ends. The spores,  $24 \times 4 \mu$ , appear somewhat wider than our form and for that reason we are segregating the *Stipa* material to the extent of naming it as a form of Sydow's species.

It should be mentioned that *St. smolandica* Eliasson on *Agrostis vulgaris* is very similar to *St. insularis*. It is associated with sterile stroma of *Phyllachora graminis*. The spores are cylindrical, and the species is evidently not at all related to *St. Agrostidis* f. *angusta*. The latter is also distinct in several ways from *Septoria nodorum* Berk. *S. nodorum* has cylindrical to subfusoid spores, typically rounded at both ends and usually slightly to distinctly constricted at the septa. The contents are not coarsely guttulate and in addition the pycnidia of *S. nodorum* are much smaller than most of those of the *Stagonospora*.

The *Stipa* material belongs in *Stagonospora* because the spores are definitely broadened, less than eight times as long as wide.

#### MACROPHOMA PHLEI TEHON AND STOUT

A fungus which we call *M. Phlei* was found on dying leaves of *Elymus triticoides* Buckl. in the plots at Mandan, N. Dak. (B. P. I. 80,893). The fungus is of no economic importance and the material is scanty. It occurs in diffuse straw-colored spots. The pycnidia are black, depressed-globose, tardily ostiolate ( $12-16\ \mu$ ), arranged in lines along the veins of the leaf,  $120-135 \times 120-204\ \mu$ , and the pycnosporos are elliptical to elongate ovate, slightly larger at one end, hyaline with pure white, opaque contents,  $28-39 \times 8.5-11\ \mu$ , mean size  $32 \times 9.4\ \mu$ .

This fungus resembles *M. Phlei* in a number of ways (20). The pycnidia, their arrangement, the shape if not the size of the spores are all very similar in the Illinois and North Dakota material. Our collection is distinguished somewhat from the type by its larger spores (FIG. 2, *b*). Those of the type are  $18-26 \times 6.4-7.7\ \mu$  and since Tehon and Stout report that their fungus is evidently mature, the material from Mandan, which also appears to be mature, may have spores too large for *M. Phlei*. The smallest spore in our material is somewhat larger than the largest of *M. Phlei*. The writer has seen similar material on *Agrostis palustris* from Newport, Oregon, with spores  $24-31 \times 9.5-11\ \mu$  (FIG. 2, *c*). Because all material seen is scanty, we prefer to leave our collections in *M. Phlei* but the description of the latter should be modified to conform to the range of the spore size indicated.

*M. Zeae* Tehon & Daniels has fusiform, hyaline to greenish spores  $17-31 \times 6.5-8.5\ \mu$  borne in extensive spots with the pycnidia ( $65-120\ \mu$ ) scattered throughout the spots. *M. Zeae* (19) therefore appears to be very different from *M. Phlei*.

#### CERCOSPORA BROMI SPRAGUE

*Cercospora Bromi* Sprague (11) is notable for the peculiar secondary conidia, which are attached and down-deflected from the first or second basal cell of the conidia. On the basis of Newhall's study (7) of a fungus that causes a disease of celery, our fungus

should be placed in the genus *Ansatospora* Newhall. Therefore *Ansatospora Bromi* (Sprague) comb. nov. is proposed for the fungus on *Bromus rigidus* Roth.

#### OPHIOCLADIUM HORDEI CAV.

On the basis of material from Wisconsin, which Davis (3) and later Greene (5) assigned to *Ophiocladium Hordei* Cav., the writer refers comparable material on the same host, *Phalaris arundinacea* L., from Moskee, Wyo., and Spearfish Creek, S. Dak., to this species. This fungus appears to be relatively common in favored locations along creeks. It produces amphigenous straw-colored to buff, later pale-brown spots on the leaves which later become chalky white with the fruiting material of the fungus. The spots when mature are elongate, striate, often  $1-2 \times 10-30$  mm. and finally are more or less confluent and covering or killing most of the leaf surface. They are emarginate or with diffuse yellow-buff surrounding the lesions. The conidiophores are in compact fascicles in neat rows between the veins of the leaf, emerging from stomata and arising from yellow to mostly hyaline compacted or serpentine hyphae. These strikingly distinct conidiophores (FIG. 2, d), which Cavara (2) certainly does not illustrate as being serpentine, are  $3-4.5 \mu$  in diameter,  $20-40 \mu$  tall, tortuous, twisted, or remarkably serpentine, particularly at the apex. The conidia are produced at the apex or on the sides of conidiophores adjacent to the apex. The spores show a slight hilum after breaking away from the conidiophores. The spores are hyaline, 1-celled with an evident wall (as shown by Cavara), which appears faintly roughened,  $11-15.5 \times 6-7 \mu$ . The spores are not numerous. Associated are smaller hyaline spores.

This fungus differs from *O. pulchella* (Ces.) Sacc. in the unusually serpentine conidiophores, the elongate-striate, not oval, lesions and in the structure of the spore wall.

*O. Hordei* is known as an obscure disease of barley in northern Europe. It has not been reported on barley in the United States and whether critical comparison with European material on barley will disclose anything more than racial differences must await possible later study.

*Ophiocladium* is generally placed under the *Micronemae* with their "hyphae" very short or obsolete, or little different from the conidia." This is obviously incorrect. Under *Macronemae* this species keys to *Ovularia*. The differences between this fungus and well recognized species of *Ovularia* are insufficient to warrant recognition of the fungus in *Ophiocladium*. The writer sees no need for the genus *Ophiocladium*, which he proposes to reduce to synonymy under *Ovularia*. He therefore proposes *Ovularia Hordei* (Cav.) comb. nov.

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## EXPLANATION OF FIGURES

FIG. 1. (All  $\times 1000$ .)

- a. Pycnospores of *Septoria digitalivora* Sprague, from type.
- b. Pycnospores of *Septoria Melicac* Pass. on *Melica scabrosa* Trin., Mandan, N. Dak.
- c. Pycnospores of *Septoria Secalis* var. *Stipac* Sprague on *Stipa Williamsii* Scribn., Mandan, N. Dak. This represents the 1- to 3-septate summer phase of this species.
- d. Pycnospores of *Septoria Andropogonis* f. *sporobolicola* Sprague on *Stipa comata* Trin. & Rupr., Mandan, N. Dak.
- e. Pycnospores of *Septoria quinqueseptata* Sprague, type.
- f. Pycnospores of *Stagonospora Agrostidis* f. *angusta* Sprague, from type.
- g. Pycnospores of *Stagonospora simplicior* Sacc. & Ber. on *Calamovilfa longifolia* (Hook.) Scribn., Mandan, N. Dak. (B. P. I. 80,884).
- h. Pycnospores of *Septoria Andropogonis* J. J. Davis on *Sphenopholis obtusata* (Michx.) Scribn., Devil's Lake at Ft. Totten (station), N. Dak., Aug. 6, 1943.

FIG. 2. (All  $\times 1000$ .)

- a. Pycnospores of *Stagonospora foliicola* (Bres.) Bubák from *Phalaris arundinacea* L., Mandan, N. Dak. (B. P. I. 80,895).
- b. Pycnospores of *Macrophoma Phlei* Tehon & Stout from *Elymus triticoides* Buckl., Mandan, N. Dak.
- c. Pycnospores of *Macrophoma Phlei* from *Agrostis palustris* Huds., six miles s. of Newport, Oregon, Dec. 18, 1937 (O. S. C. 39, W. B. Cooke coll.).
- d. Fascicle of conidiophores and detached conidia of *Ovularia Hordei* (Cav.) Sprague on *Phalaris arundinacea* L., Moskee, Wyo.

## ELSINOË ON RANDIA

ANNA E. JENKINS AND A. A. BITANCOURT

(WITH 1 FIGURE)

In 1937 in conversation with the senior writer, J. A. Stevenson recalled that a disease of similar symptoms to those of sour orange scab caused by *Elsinoë Fawcetti* Bitanc. and Jenkins, which he had studied in Puerto Rico, was often present on *Randia mitis* L., a common shrubby plant on the island. Upon request, W. A. McCubbin, then stationed at San Juan, made several collections of fruits of *R. mitis* showing abundant scabbing such as that Mr. Stevenson had remembered. On specimens consisting of branches with the fruit still attached it was noted that leaves and stems also were infected, but much less conspicuously and abundantly so than fruits. Cultures made by the senior writer from fruits sent in 1938 yielded typical vegetative growth of *Elsinoë*, and ascomata of this genus were discovered on the gathering of 1939, which was studied by the junior writer.

Evidence that "scab of Randia" is widespread and of long standing in the West Indies is afforded by the fact that typical lesions are present on various specimens of *Randia mitis*, as well as on other species including *R. parvifolia* Lam., in the U. S. National Herbarium, Washington, D. C., and the herbarium of the New York Botanical Garden, N. Y. Two of these specimens, one bearing the date 1877, will be cited in connection with the description of the *Elsinoë* on *Randia*, which follows:

***Elsinoë puertoricensis* Jenkins & Bitanc. sp. nov. FIG. 1.**

Leaf spots generally few, circular to subcircular, measuring up to 1 mm. in diam., visible on both leaf surfaces, with the central part thin, parchment-like, translucent, often falling away, margin of well developed spots forming a salient ring, waxy in appearance, upper surface of spots including the nerves which traverse them "light vinaceous cinnamon,"<sup>1</sup> "vinaceous cinnamon," or "cinnamon

<sup>1</sup> Names of colors in quotation marks are according to "color standards and color nomenclature" by Robert Ridgway (1912).



buff," becoming somewhat paler toward the margin, the surrounding leaf tissue water-soaked in appearance becoming "olivaceous black" and "fuscous black," fruit spots circular or nearly so, about 1 mm. in diam., scattered or confluent forming irregular areas, dirty white at the center, sometimes dotted by the dark ascomata of the *Elsinoë*, separated from the surrounding tissue by a fine, pale to dark line of demarcation, conspicuously raised and wartlike and surrounded by a more or less pronounced fissure or flattened with the border, of varying width, merging with that of adjoining lesions where spots are grouped; ascomata erumpent, measuring 50–150  $\mu$  in diam. by 20 to 50  $\mu$  in thickness, forming a pulvinate relatively homogeneous mass of pseudoparenchyma, often darkened in the peripheral region, merging into a hyaline prosenchyma which is intermingled with the superficial cells of the cicatricial periderm forming the external part of the lesion, without a well defined epithecium, asci irregularly distributed throughout the pseudoparenchyma including the peripheral region, in the specimens examined, occasionally protruding above the surface of the ascoma, globose with internal wall noticeably thickened in the apical region; faveola sometimes distinguishable, 14–20  $\mu$  in diam., containing 8 ascospores; ascospores hyaline, 1 to 3 septate, measuring 11–14  $\times$  4–5  $\mu$ .

Maculae in foliis amphigenae, sparsae, circulares vel subcirculares, usque 1 mm. in diam., centro tenui translucenti, margine elevato, annuliformi, brunneo, ceraceo, interdum zona nigrescenti circumdatae; lesiones in fructibus dispersae vel in caespites irregulares aggregatae, subelevatae vel verruciformes, centro glabro albedo, margine angusto pallido usque fusco interdum fissuratae; ascomata erumpentia, 50–150  $\times$  20–50  $\mu$ , pseudoparenchyma comparative homogenum obscurum componentia, superficiem versus leniter obscuriora, epithecio non evoluto; asci in pseudoparenchyma parte periphericali inclusa irregulariter distributa, interdum ad superficiem ascomatis protrudentes, globosi usque obovati vel ellipticales, 14–20  $\mu$  in diam.; ascospores usque 8, hyalinae, 3-septatae, 11–14  $\times$  4–5  $\mu$ .<sup>2</sup>

<sup>2</sup> Latin diagnosis prepared by Miss Edith K. Cash.

FIG. 1. *Elsinoë puertoricensis* Jenkins & Bitanc. on *Randia mitis* from Puerto Rico. A, On leaves, fruits and stems of specimens from Arecibo, P. R., Mar. 7, 1939, W. A. McCubbin. a, leaf spot intact; b, leaf spot with center fallen away.  $\times 1$ . B–C, Fruits from Vega Baja, Feb. 8, 1938, W. A. McCubbin.  $\times 6$ . D, F, and G, Sections of ascomata from same specimens. a, asci with ascospores; b, malformed host tissues.  $\times 500$ . E, Culture on potato medium (Thaxter).  $\times 1$ . Photographs by M. L. F. Foubert (A–C, and E) and by Bitancourt (D, F, and G).



FIG. 1.

**DISTRIBUTION :** Producing a conspicuous scab on fruits of *Randia mitis* L. and other species of this genus of the Rubiaceae, including *R. parvifolia* Lam., leaves and stems also affected, West Indies including Martinique, Puerto Rico and Haiti.

**SPECIMENS EXAMINED:**<sup>a</sup> On *Randia mitis* L. Martinique: 1877, Père Duss 990 (USNH 845947, fragment in USM) ; Puerto Rico: Palo Seco, Oct. 19, 1937, W. A. McCubbin (USM 72729; IB 2965) ; Vega Baja, Feb. 8, 1938, W. A. McCubbin. Type (USM 73729; IB 2966) ; Arecibo, Mar. 7, 1939, W. A. McCubbin (USM 73056; IB 4391) ; on *R. parvifolia* Lam., Haiti, Vic. Port de Paix, Dec. 22, 1928, E. C. Leonard 1103 (USNH 1450080).

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<sup>a</sup> Symbols employed in citing specimens are as follows :

- USM    Mycological Collections of the Bureau of Plant Industry, Soils and  
       Agricultural Engineering, Beltsville, Md.  
IB     Secção de Fitopatologia do Instituto Biologico de São Paulo, São  
       Paulo, Brazil.  
USNH   United States National Herbarium, Smithsonian Institution, Wash-  
       ington, D. C.

# ISOLATES INTERMEDIATE BETWEEN STACHYBOTRYS AND MEMNONIELLA

ROBERT K. ZUCK

(WITH 2 FIGURES)

## INTRODUCTION

Interest in this country in *Memnoniella echinata* (Rivolta) L. D. Galloway arose with reports from Australia that this fungus was being used for testing variously treated cotton cloth for mildew resistance. Subsequently, several workers have found that it is not rare in this country. The writer and his associates have frequently observed *M. echinata* on mildewed cloth removed from soil contacts as well as from above-ground exposures ranging from Madison, Wis., to New Orleans, La. That it is a rather common soil organism here is suggested by the fact that it occurs regularly on fabric test specimens removed from soil burial tests using Chester Loam from Maryland, Miami Silt Loam from Indiana, Carlisle Muck from Michigan, and Carrington Loam from Nebraska. Thus despite somewhat limited records as to its occurrence, it seems probable that this organism is of worldwide distribution.

*Stachybotrys*, particularly *S. atra* Corda, has long been known to occur here under conditions similar to those described above. *S. atra* has been used to a limited extent during the past several years as a test organism for evaluating mildew resistance of fabrics.

In reviewing the genus *Stachybotrys*, Bisby (1) places *M. echinata* under the tentatively emended *S. subsimplex* Cooke as similar to the latter species, "except in having catenulate spores," suggesting that a reduction in slime production would allow for the retention of spores in chains. The rarity of *M. echinata* led him to view this species with suspicion. In accepting the species *S. subsimplex*, Bisby bases his conclusions on dried specimens, lost cultures, and prepared slides. The distinguishing feature of this

species is that the phialophores are "generally simple" in contrast to the branched phialophores of *S. atra*. In tentatively disposing of *M. echinata*, Bisby suggests that it may be "an unusual or abnormal development of *Stachybotrys*."

During the course of isolating and purifying cultures of so-called *M. echinata*, the writer observed four isolates of an intermediate nature between *Stachybotrys* and *Memnoniella*, as well as four isolates which, up to the present, have remained stable in the characters Galloway lists for *M. echinata*. No *Stachybotrys* that has been isolated or received in this laboratory falls into the description of *S. subsimplex* supplied by Bisby. However, the *Stachybotrys*-like phase of the intermediate isolates is much like the description of *S. subsimplex*.

#### CULTURES AND METHODS

Four cultures of *Memnoniella*, Serial Nos. 2, 52, 85, and 86, were examined. These had been secured from the NDRC Tropical Fungus Culture Collection at Harvard, having been sent to Dr. Wm. H. Weston through the courtesy of the Mycological Panel of the Australian Scientific Liaison Bureau, originally isolated from deteriorated material from the Southwest Pacific. Nos. 2, 52, and 86 were found producing the elliptical to oval, roughened, black spores in slimy heads as in *Stachybotrys*, as well as the typical, spherical, roughened, catenulate black spores of *Memnomella*. Culture 85 revealed only typical *Memnoniella* spores in chains. Culture 2 produced only an occasional *Stachybotrys* type of head.

A culture isolated in this laboratory from cotton duck showing typical *M. echinata* under the microscope, numbered M64, also produced in culture both types of spores in slimy heads and long chains. The mildewed duck was submitted by the Philadelphia Navy Yard. An isolate, designated M92, made by the writer from a cotton duck strip from soil contact in compost continues, however, to resemble *M. echinata* as originally described and illustrated.

Two cultures, numbered 1229.2 and 1331.1, isolated eight years ago in this laboratory and maintained to the present under the designations of *Stachybotrys* and *Stachybotrys papyrogena*, re-

spectively, when revived this year were found to be typical *M. echinata*. The note made at the time of isolation and identification indicates that the culture produced black spores in chains. Thus it appears that these cultures were mislabeled, rather than that they have changed. .

Single spore isolates of all cultures except 1229.2 and 1331.1 were made using a micromanipulator and placing the spores on a cotton extract agar described later. All cultures which exhibited the two spore types gave rise in single spore culture to the same intermediate type, whether from the oval *Stachybotrys*-like spore or the spherical *Memnoniella*-like spore. The two cultures which showed only the *Memnoniella* phase continue to do so in single spore cultures. Cultures 1229.2 and 1331.1 are from single-spore isolates originally.

The medium used consisted of an extract of 10 grams of ginned cotton fibers in 100 ml. of distilled water. The fibers are allowed to become thoroughly wet and then squeezed several times until most of the water is removed. This is then made up with C.P. chemicals as follows: 2.22 grams  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ , 2.09 grams  $\text{K}_2\text{HPO}_4$ , 2.86 grams  $\text{KH}_2\text{PO}_4$ , and 3.00 grams  $\text{NH}_4\text{NO}_3$ , and 1 per cent dextrose. Owing to retention of some of the distilled water by the cotton fibers after squeezing, the volume is restored with distilled water. Two per cent agar was used. The medium is then sterilized at 15 lbs. for 15 minutes. Robbins and Ma (3) and Robbins and Schmitt (4) have shown cotton fibers to contain at least vitamins  $\text{B}_1$ ,  $\text{B}_6$ , biotin, and an unidentified organic acid.

Growth on the medium described above was abundant. All observations and photomicrographs were made from material grown on this medium. Growth was at room temperatures and in the light and dark of day and night.

Incidentally, a rapid method for purifying cultures of *Memnoniella* of both bacterial and fungal contaminants used in the course of this work may be of interest to other workers. Strips of gray duck (not bleached duck)  $\frac{1}{2}$  inch in width and four inches long were placed in test tubes, the tubes plugged, and sterilized in the autoclave at 15 lbs. pressure for 15 minutes. These strips then were inoculated with pieces of agar containing the contami-

nated culture. The inoculated tubes were then placed in tightly closed Mason jars with about an inch of water in the bottom. Incubation was at room temperature. After a period of three or four weeks, the *Memmoniella* sporulates abundantly, with the phialophores on both sides of and at right angles to the substratum, thus facilitating the removal of spores with a needle. The moisture content of the cloth is apparently too low to permit the development of bacteria and many types of contaminating fungi that require mono- or disaccharides are automatically eliminated.

#### OBSERVATIONS

The *Stachybotrys*-like phase of the intermediate cultures is most conspicuous at the advancing edge of a colony. As the colony becomes older, the *Memmoniella* phase predominates and the cultures might be considered pure *Memmoniella*, unless carefully scrutinized from several mounts. The colonies are typically *Memmoniella* in general characters, being buff to almost salmon-pink (on the reverse) with sporulation most abundant in the center and spreading outward.

Figure 1A shows the typical *M. echinata* type of spores in chains. This is from culture M64. Also from culture M64 is the condition shown in figure 2, where the same hypha gives rise to a *Stachybotrys*-like head of oval spores and to a *Memmoniella*-like head of catenulate, rounded spores. Both phases, as well as branching of the phialophore, are shown in figure 1B, from culture SN86.

Although no photomicrograph is shown, chains of *Memmoniella* spores arising from a head of phialides have been observed surmounted by a cluster of the oval spores of the *Stachybotrys*-like phase. This is particularly so in culture M64. Apparently the same head of phialides can produce both spore types.

A preliminary experiment, using M64 as a source of inoculum, was conducted in which spores were dusted on a sterile unsized

FIG. 1. A, *Memmoniella* phase of culture M64; B, branched phialophore bearing *Stachybotrys*-like spores at right and *Memmoniella*-like spores on the vertical branch. From culture SN86. In Patterson's Mounting medium with erythrosin, after fixing of spores in chains with  $\frac{1}{2}$  ethanol 95 $\frac{1}{2}$  glacial acetic acid. (Photomicrographs by M. L. Jaeger)  $\times 1100$ .



FIG. 1



gray cotton duck strip in a test tube. This tube was placed in a sealed Mason jar with an inch of water and incubated for 6 weeks at 86° F. in the dark. The inoculum contained both spore types. Although sporulation was abundant, microscopic examination failed to reveal the two phases. Only the *Memnoniella* phase



FIG. 2 *Memnoniella* phase at right with *Stachybotrys* phase at left on the same hypha, from culture M64 Preparation the same as for Fig 1 (Photomicrograph by M. L. Jaeger)  $\times 1100$

could be found. The tendency to produce both phases, then, is also governed by environmental conditions.

Permanent Clearcol mounts of each single-spore isolate culture have been made. The cultures are being maintained at the present

#### DISCUSSION

The condition, in which two phases occur on the same hypha or branched phialophore, suggests that *Memnoniella* and *Stachy-*

*botrys* may be segregates from the intermediate type, or that the intermediate type is a hybrid resulting from a perfect stage yet to be discovered. Whatever the explanation, the demarcation between *Stachybotrys* and *Memmoniella* is rendered less clear by these isolates. The fact that Galloway's (2) isolate, from which the combination of names was made by him, upon being examined by Bisby ten years after isolation, continues as pure *Memmoniella echinata*, would indicate, along with the two eight-year-old isolates in this laboratory, that *M. echinata* is a valid entity. Likewise, the recognition by G. Smith (5) of *S. atra*, as well as by Bisby, would indicate it to be a valid, stable species. However, the scant description by Bisby, the loss of cultures, and the inability of the present writer to find a culture corresponding to *S. subsimplex*—unless this designation may be applied to the intermediate phase described in this paper—would seem to raise some question as to the validity of the species.

The erection of a specific name for the intermediate phase is probably of questionable value.

Should further study reveal perfect stages, perhaps the intermediate phase could be demonstrated experimentally. Until such an eventuality, however, it seems sufficient to call attention to this phenomenon in order that experimental and taxonomic workers may be aware that this condition exists.

#### SUMMARY

1. Isolates of an intermediate nature between *Memmoniella* von Höhnelt and *Stachybotrys* Corda have been observed.

2. *Stachybotrys*-like slimy heads of elliptical to oval spores and *Memmoniella*-like heads of chains of spherical spores can occur on separate phialophores on the same hypha, or separately on the two phialophores of a branched phialophore.

3. Single-spore isolates of cultures exhibiting this phenomenon continue to do so, whether the single spore is of the elliptical *Stachybotrys* type or of the spherical *Memmoniella* type.

4. Isolates stable for the characters of *Memmoniella echinata* for eight years are also reported.

5. The form genera *Memnoniella* and *Stachybotrys* are considered to be valid entities.

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## STUDIES IN THE GASTEROMYCETES XII. FIVE SPECIES OF TYLOSTOMA WITH MEMBRANOUS EXOPERIDIA

W. H. LONG

(WITH 5 FIGURES)

In a study of several thousand specimens of *Tylostoma*, including numerous species, I was surprised to find that only five species among all these plants had typical membranous exoperidia, while a study of the literature on this genus does not indicate any additional species with such exoperidia. The results of my studies are embodied in this paper. It is interesting to note that the five species are divided among the three mouth sections as follows: 2 in the fibrillose section, 2 in the tubular, and 1 in the indefinite mouth group.

The five species with membranous exoperidia are as follows: *Tylostoma poculatum* White, *T. Lloydii* Bresadola, *T. involucratum* Long, and two new species described in this paper.

*TYLOSTOMA POCULATUM* White, Bull. Torr. Club 28: 431. 1901.

*Tylostoma minutum* White, Bull. Torr. Club 28: 430. 1901.

*Sporophore* consisting of sporocarp, stipe and a slightly enlarged base, originating from 2 to 3 cm. below the surface of the soil. *Sporocarp* subglobose to slightly depressed-globose, 4–15 mm. high by 7–20 mm. wide, usually attached firmly to stem apex, but easily breaking off in or near the socket. *Exoperidium* strongly and permanently membranous, drying into a fragile envelope, early deciduous in pieces, usually leaving lacerate fragments of the dried membrane around the top of the peridial sheath, inner surface tilléul buff (Ridgway). *Peridial sheath* persistent, a thick band of agglutinated hyphae and sand, 2–7 mm. broad, often with a somewhat cup-shaped upper margin composed of the fragments of the exoperidium. *Endoperidium* perfectly smooth, usual color tilléul buff, but sometimes when freshly emerged vinaceous buff to fawn color, membranous. *Mouth* fibrillose, often seated in a distinct depression (FIG. 1), usually circular, but often elliptical.

mouth opening 1–2 mm. in diameter, surrounded by a definite fibrillose mat, 2–4 mm. across, elevated when young, but becoming nearly plane in age, concolorous with the endoperidium, but sometimes slightly darker. *Collar* inconspicuous, close to stem, 1–2 mm. distant. *Stipe* 1–3 cm. long by 2–3 mm. thick, even, terete, often striate above, white when freshly emerged but turning light brown (wood brown) on weathering, walls thin and fragile, easily breaking especially near or in the socket, often with a spongy cushion of hyphae and sand extending for  $\frac{3}{4}$  of the distance up the stem (FIG. 1, bottom row); this cushion is big at base but tapers above, it easily falls off when dry leaving a white friable area on stem. *Volva* none. *Radicating base* rare, roots short (FIG. 1, 2nd row from bottom). *Base* slightly enlarged. *Gleba* cinnamon rufous. *Capillitium* hyaline, branched, 4–7  $\mu$  thick, ends square, lumen small, septa rare, some slightly swollen. *Spores* subglobose to oval, often irregular and angular, 4.2–6  $\mu$  in diameter, rarely 7  $\mu$ , usual size 5.6  $\mu$ , some shortly pedicelled. *Epispore* ferruginose, smooth to verruculose.

The color of the endoperidium of the type of *T. poculatum* is a tilleul buff and not fawn color as given by White (l.c.). This is the usual color for this species.

ILLUSTRATIONS: White, the Tylostomaceae, Bull. Torr. Club 25: pl. 34, figs. 4–6. Lloyd, Myc. Writ. 2: pl. 83, fig. 2, fig. 3 as *T. tuberculatum* and figs. 4 and 5 as *T. subfuscum*.

HABITAT: Solitary, gregarious or rarely caespitose, in sand or sometimes in black soil, in open or in partial shade of mesquite brush (*Prosopis juliflora*), or other desert shrubs.

DISTRIBUTION: NORTH AMERICA. ARIZONA. SANTA CRUZ COUNTY, 6–8 miles from Nogales on Highway 89, elevation 3857 feet, W. H. Long and Victor O. Sandberg, February 19, 1934, 7625 (13 plants), June 4, 1938, 8305 (6 plants). W. H. Long and David J. Stouffer, September 11, 1941, 9630 (6 plants), 9631 (14 plants). PIMA COUNTY, 8 miles from Tucson on road to Sabino Canyon, elevation 2400 feet, W. H. Long and Victor O. Sandberg, September 22, 1934, 8019 (6 plants). COCONINO COUNTY, Kaibab Lodge, elevation 9800 feet, W. H. Long, October 22, 1933, 7881 (48 plants). Flagstaff, elevation 6894 feet, W. H. Long, May 6, 1934, 7693 (62 plants). YAVAPAI COUNTY, Prescott, elevation 6000 feet, W. H. Long, October 15, 1933, 7755 (10 plants). Victor O. Sandberg and Carl Butler, September 8,

1934, 7955 (4 plants). *Victor O. Sandberg*, January 2, 1934, 7905 (32 plants).

NEW MEXICO. SOCORRO COUNTY, Tres Montosos Mts. near Magdalena, elevation 6700 feet, *E. A. Frazier*, October 11, 1934, 7990 (5 plants). DONA ANA COUNTY, Jornada Experimental Range, elevation 4150 feet, *Ivan H. Crowell*, *W. H. Long* and *Victor O. Sandberg*, May 2, 1937, 8181 (4 plants). *W. H. Long*, November 12, 1938, 8259 (3 plants), 10032 (1 plant), October 2, 1939, 8404 (4 plants). *W. H. Long* and *David J. Stouffer*, September 7, 1941, 9549 (59 plants), September 8, 1941, 9604 (15 plants), 9611 (19 plants), 9707 (5 plants). VALENCIA COUNTY, east of Rio Grande River, 4 miles below Belen bridge, elevation 4785 feet, *W. H. Long*, September 18, 1941, 9682 (8 plants), September 24, 1941, 7919 (7 plants). *W. H. Long* and *David J. Stouffer*, December 6, 1941, 9927 (2 plants). LUNA COUNTY, 10 miles west of Deming, along highway 70, elevation 4300 feet, *W. H. Long* and *David J. Stouffer*, September 12, 1941, 9643 (11 plants), September 13, 1941, 10009 (11 plants). SANDOVAL COUNTY, 2 miles south of Bernalillo highway 85, elevation 5100 feet, *W. H. Long*, July 12, 1941, 9439 (11 plants). 4 miles east of San Ysidro, near state highway 84, elevation 6000 feet, July 12, 1941, 9408 (3 plants). 5 miles west of San Ysidro near state highway 84, elevation 6200 feet, July 9, 1941, 9385 (1 plant). 6 miles from Cuba, near Eureka Lodge in Jemez Mts., elevation 8300 feet, *W. H. Long*, October 13, 1933, 7777 (4 plants). CHAVEZ COUNTY, in oak shinnery (*Quercus harvardii*), 34 miles east of Roswell on highway 380, elevation 3400 feet, *W. H. Long* and *David J. Stouffer*, April 19, 1942, 10042 (48 plants). LINCOLN COUNTY, 8 miles south of Oscuro, elevation 5000 feet, *W. H. Long* and *David J. Stouffer*, April 18, 1942, 10092 (1 plant). Juniper sand hill area 25 miles west of Corona, elevation 7000 feet, *David J. Stouffer*, December 15, 1941, 9972 (3 plants), September, 1941, 9847 (4 plants). *W. H. Long* and *David J. Stouffer*, September 17, 1941, 9746 (4 plants). Pinos Mts. Area, elevation 7000 feet, *David J. Stouffer*, November 27, 1940, 9296 (2 plants). Jicarilla, elevation 6560 feet, *David J. Stouffer*, October 31, 1941, 9864 (2 plants). In vicinity of Corona, elevation 6500-7200 feet, *David J. Stouffer*, April 21, 1940, 7830 (49

plants), July 1941, 9530 (5 plants), June 2, 1941, 9426 (2 plants), July 23, 1941, 9414 (3 plants). *W. H. Long and David J. Stouffer*, April 21, 1941, 11042 (9 plants), September 17, 1941, 9789 (14 plants), September 15, 1941, 9697 (2 plants), September 6, 1941, 9575 (7 plants). Mescalero-Apache Indian Reservation, in White Mt. area, elevation 6560 feet, *Elmo Traylor*, October 15, 1941, 9934 (8 plants). TORRENCE COUNTY, 8 miles S.W. of Vaughn, elevation 5950 feet, *David J. Stouffer*, June 15, 1941, 9418 (6 plants).

TEXAS. DENTON COUNTY, Denton, elevation 620 feet, *W. H. Long* 2062 (3 plants) in Lloyd Myc. Coll. 30697.

NEBRASKA. BROWN COUNTY, Long Pine, February 3, 1896, *J. M. Bates* 351 (3 plants) in Lloyd Myc. Coll. 33642. CUSTER COUNTY, Calloway, *J. M. Bates*, November 11, 1902, Bates 2689 (20 plants) in Lloyd Myc. Coll. 33644. *J. M. Bates*, December 9, 1902, from Ell. & Ev. Fungi Columb. 1889 (3 plants) in New York Botanical Herbarium. Oconto, *J. M. Bates*, September 30, 1902 (12 plants) in Lloyd Myc. Coll. 30830 as *T. subfuscum*.

WASHINGTON. YAKIMA COUNTY, Sunnyside, *J. S. Cotton*, comm. *C. V. Piper*, June 1900, Fungi of Washington, 739 (4 plants), in Lloyd Myc. Coll. 30834 as *T. tuberculatum*.

AUSTRALIA. *F. M. Reader*, comm. *D. McAlpine*, in Lloyd Myc. Coll. 30827 (9 plants). 4 of these plants are shown in Myc. Writ. 2: plate 83, fig. 4 as *T. subfuscum*.

SOUTH AUSTRALIA. ADELAIDE COUNTY, Adelaide. *J. Burton Cleland* (751) in Lloyd Myc. Coll. 30869 (5 plants).

NEW ZEALAND. WELLINGTON COUNTY, Wellington. *G. H. Cunningham* (67), September 1919, in Lloyd Myc. Coll. 50740 (40 plants).

"Lone Pine," Nebraska, given by Miss White as type locality for *T. poculatum* is incorrect, it should be spelled "Long Pine."

Fifty American collections of *Tylostoma poculatum* containing 544 plants were studied, each collection identical in every detail as to external characters. All of the collections had membranous exoperidia and were typical in size, shape and color for *T. poculatum*.

These collections ranged from Texas on the south to the state of Washington on the north, and from 620 feet elevation to 9800 feet.

from semidesert areas in Arizona and New Mexico, to less arid conditions in Texas, northern Arizona and New Mexico and in the state of Washington. Some were from areas where snow does not occur, others were found where the winters were severe with a snow fall of 3-4 feet. The soil was usually sandy, but 3 collections came from old stock corrals with rich soil and 2 from a loamy, rich, black soil. This great range in habitat is shown in detail under "Distribution" for each collection.

Forty-four of these collections were examined with a compound microscope to determine the glebal characters, especially the size, shape and markings of the spores for each collection. Especial effort was made to determine whether each had smooth or rough spores.

The microscopic examination gave the following results: 12 of the collections showed verruculose spores, 12 gave a mixture of verruculose and smooth spores on the same slide, while 22 of the collections gave only smooth spores, yet all of these collections were undoubtedly the same species in spite of the spore variation as to markings. 1 to 3 sporocarps in each collection were examined under the microscope since this was considered sufficient to get the characteristics of the spores. In the collection from the 9800 feet elevation, 3 separate sporocarps were examined, 2 gave verruculose spores while 1 gave both verruculose and smooth spores.

In view of the above data the spore markings of *T. poculatum* should be listed as smooth to verruculose and not just smooth. I cannot see any valid reason why a species should not have minor variations in spore markings as well as in their shape, size, etc. Also we have minor variations in macroscopic characters such as size and color within narrow limits of sporocarp and stem, but the membranous exoperidia is a fixed character for a given species and not subject to variation.

I have examined the type material of both *Tylostoma poculatum* and *T. minutum* and find that they are unquestionably the same species. In the type of *T. minutum*, I found only a few verruculose spores, most of the spores being smooth.

Figure 1 shows 25 specimens (natural size) of *T. poculatum* taken from 20 different collections. The bottom row shows 5



plants with spongy cushion bases, each plant from a different collection, ranging from the hot arid sand dunes of New Mexico to the cold regions of higher altitudes. The 2 plants with "black" stems came from 9800 and 8300 feet elevation respectively, while the other 3 plants in this bottom row were from lower elevations. One plant has the cushion scraped off to show the white stem inside the cushion. The 2nd row of plants from the bottom shows 4 plants with radicating roots. The upper 2 rows show the various sizes of plants, and characters of stems and heads. Several of the plants show the slight depression in which the peristome is often situated.

The utter futility of attempting to differentiate between species by their spore characters alone without taking into consideration their external characters is well illustrated by Cunningham (1942) in his discussion of *Tylostoma obesum* where he lists as synonyms the following species: *T. poculatum*, *T. gracile*, *T. kansense* and *T. Lloydii*. Even a layman can see from a casual comparison of figures 1, 2, and 3 that the 3 plants are as diverse in all their macroscopic characters as 3 species of *Tylostoma* could possibly be. They do not have even a superficial resemblance to each other and yet according to Cunningham they are the same. *T. poculatum* and *T. Lloydii* have membranous exoperidia, but the American version of *T. obesum* does not. *T. kansense* does not have a membranous exoperidium and has an entirely different mouth from any of the 3 others. Its mouth is indefinite and lacerate, it is also a white plant having both stem and endoperidium white. Now as to *T. gracile*, I have before me a box from the New York Botanical Garden marked "*Type of Tylostoma gracile White.*" It contains a small specimen of *Chlamydomys meyenianus* and nothing else so apparently "*T. gracile*" was based on this specimen. This does not seem possible and yet this is the only authentic material of "*T. gracile*" known to exist. Furthermore the original *T. obesum* as published by Cooke & Ellis (1878) in Grevillea has a tubular mouth judging from the original description and figures, and it is so listed by Saccardo (1888) in Sylloge Fungorum, being placed under the *Eutylostoma* or tubular section. The American plant supposed to be the co-type is quite a different plant having a fibrillose mouth and differing in external charac-

ters from the plant described by Cooke & Ellis. Miss White (l.c.) was worried by these discrepancies, but passed them off by suggesting that the Cooke & Ellis plants were probably immature, though how this could change a tubular mouth to a fibrillose one is hard to understand. The statement that the American plant which Ellis retained when he sent the others to England is the same species does not make it true. It is not uncommon to find more than 1 species of *Tylostoma* mixed in a given collection. The determining factor in assigning the American plant to *T. obesum* was the similarity of the spore characters and such similarity cannot be depended upon for identification purposes, as is well shown in *T. poculatum*, *T. Lloydii* and *T. obesum* (American version). What our American plant described and figured by White and Lloyd is I do not know, possibly an undescribed species.

I find that spore markings are very unsatisfactory criteria for differentiating many species, especially those from arid regions, since most of them have very similar spores and yet the external characters are so different that they could not be the same species. That you can determine a species of *Tylostoma* from the spore markings alone is a myth, as far as my specimens are concerned.

I usually make 3 separate mounts from each sporocarp. 1 in water, 1 in chloral hydrate and 1 in benzoazurine. The water mount gives the true colors of spores and capillitium and usually the markings of the epispore. My findings are then checked in chloral hydrate and benzoazurine mounts. An oil immersion objective is used for all spore measurements and panchromatic films with the camera stopped down to 64 U. S. are used for making the photographs.

TYLOSTOMA LLOYDII Bresadola in Petri, Ann. Myc. 2: 423. 1904.

FIG. 2.

*Sporophore* consisting of sporocarp, stipe and bulbous base, originating  $1\frac{1}{2}$ –3 cm. below the surface of the leaf debris but still in the debris. *Sporocarp* suglobose, 5–8 mm. high by 7–12 mm. wide, firmly attached to the stem apex. *Exoperidium* permanently membranous, early deciduous in pieces or flakes. *Peridial sheath* persistent, membranous, a thin lacinate narrow, irregular band around base of sporocarp, margined with white, walnut brown, 3–5 mm. broad. *Endoperidium* papyraceous, perfectly

smooth, walnut brown to pecan brown. *Mouth* fibrillose, often seated in a decided circular depression, an irregular circular orifice, 1-2 mm. in diameter, peristome white, 3-4 mm. across, plane in material at hand. *Collar* definite, irregularly laciniate, projecting around stem, about 1 mm. long and 1-1½ mm. distant from stem. *Stipe* slender, terete, tapering toward apex, more or less curved, 4-8 cm. tall by 2-3 mm. thick at apex and 4-5 mm. at base, with appressed brown scales (Roods brown), more or less deciduous, leaving the stem mikado brown; surrounded at the base with a volvoid structure consisting of the lacerate membranous fragments of the upper part of the cortex, dark brown (Roods brown), often reflexed, 2-3 mm. high. *Bulb* a mass of white mycelium interwoven in the leaf debris, 10-15 mm. across. *Gleba* cinnamon color. *Capillitium* hyaline, thick walled, irregular, 3-7  $\mu$  thick, septa rare, slightly swollen. *Spores* 3.5-4  $\mu$  diameter. *Epispore* smooth.

**HABITAT:** gregarious or caespitose under shade of trees in thick leaf debris.

**DISTRIBUTION:** OHIO near Cincinnati, *Prof. W. H. Aiken*, in Lloyd Myc. Coll. 4498 (7 plants); also in herbarium of Bresadola.

**ILLUSTRATIONS:** Bresadola in Petri. Ann. Myc. 2: pl. 6, fig. 4, and 1 text figure; Lloyd Myc. Writ. 2: pl. 82, figs. 5-8.

Bresadola (1904) states the mouth is oblong, 1½ × 2 mm., slightly protruding. Lloyd (1906) says the mouth is at first raised, shield-shaped, fibrillose. In the 7 specimens at hand the mouths must be old as they are not oblong, but irregularly orbicular and plane, having traces of the shield-shaped fibrillose mouths mentioned by Lloyd. The sub-cinereous appearance mentioned by Bresadola is found on several of the sporocarps especially just above the peridial sheath, but on only a portion of these heads while the general color is brown. This is the only species of *Tylostoma* known to me that has a white fibrillose peristome.

**TYLOSTOMA INVOLUCRATUM** Long, Mycologia 36: 330-332. 1944.

This species was recently described by me (1944), hence it is not necessary to repeat the data given then; however, additional facts on distribution have since been obtained and these are given here.

**DISTRIBUTION:** CALIFORNIA. SAN BERNARDINO COUNTY. San Bernardino, elevation 1080 feet, *S. B. Parish*, Lloyd Myc. Coll.

53170 (3 plants) and Lloyd 52541 (1 plant). COLORADO. EL PASO COUNTY, Colorado Springs, elevation 5900 feet, *F. K. Vreeland*, Lloyd Myc. Coll. 53156 (3 plants). ARIZONA. PIMA COUNTY, near Tucson, elevation 2400 feet, *David Griffith* (2239), January 1901, Lloyd Myc. Coll. 34491 (2 plants); Papago Indian Reservation, Santa Rosa Ranch, Children's Shrine, elevation 2300 feet, July 10, 1942, *Paul C. Lightle*, 10265 (3 plants) in Long Herb. NEW MEXICO. SAN JUAN COUNTY, Chaco Canyon, elevation 6233 feet, *F. K. Vreeland*, in Lloyd Myc. Coll. 53165 (1 plant).

This extends the range of this species to 4 states, Arizona, California, Colorado and New Mexico.

***Tylostoma xerophilum* sp. nov. FIG. 5.**

*Sporocarp* globoso usque depresso-globoso, 4-5 mm. alto, 6-8 mm. lato. *Exoperidio* membranaceo, brunneo, toto secedente. *Endoperidio* toto levi, papyraceo, albo. *Orc* regulari integro, prominenti, mammoso, minuto. *Stipite* tenui, 15-25 mm. alto, 2-3 mm. crasso, brunneo. *Sporis* subglobosis, 4-5 $\mu$ . *Episporio* granuloso, fulvo.

*Sporophore* consisting of sporocarp and stipe. *Sporocarp* subglobose to depressed-globose, 4-5 mm. high by 6-8 mm. wide, firmly attached to stem apex. *Exoperidium* strongly and permanently membranous, outer surface walnut brown covered with a sandy layer, inner surface white, drying to a thin, very fragile membrane deciduous in flakes, leaving lacerate shreds of dried membrane around top of the peridial sheath. *Peridial sheath* a thin membranous band under the head, 3-4 mm. wide, with an irregular border, semi-deciduous. *Endoperidium* white, perfectly smooth, papyraceous. *Mouth* tubular, small, circular, prominent. *Collar* inconspicuous, close to stem. *Stipe* very slender, weak, easily breaking especially near base, straight, uniform; 1½-2½ cm. long by 2-3 mm. thick, often striate on part above ground, smooth below, pecan brown. *Volva* none. *Radicating base* none. *Gleba* cinnamon color. *Capillitium* hyaline, same diameter as spores, septa slightly swollen. *Spores* subglobose, 4-5  $\mu$  in diameter. *Epispore* sayal brown, minutely verruculose.

**HABITAT:** Solitary or in small groups in partial shade, in mesquite-catclaw flats (*Prosopis-Acacia*).

**DISTRIBUTION:** ARIZONA, SANTA CRUZ COUNTY, 7 miles from Nogales on state highway 89, elevation 3857 feet, *W. H. Long and Victor O. Sandberg*, November 13, 1936, 8847 (7 plants). *W. H.*

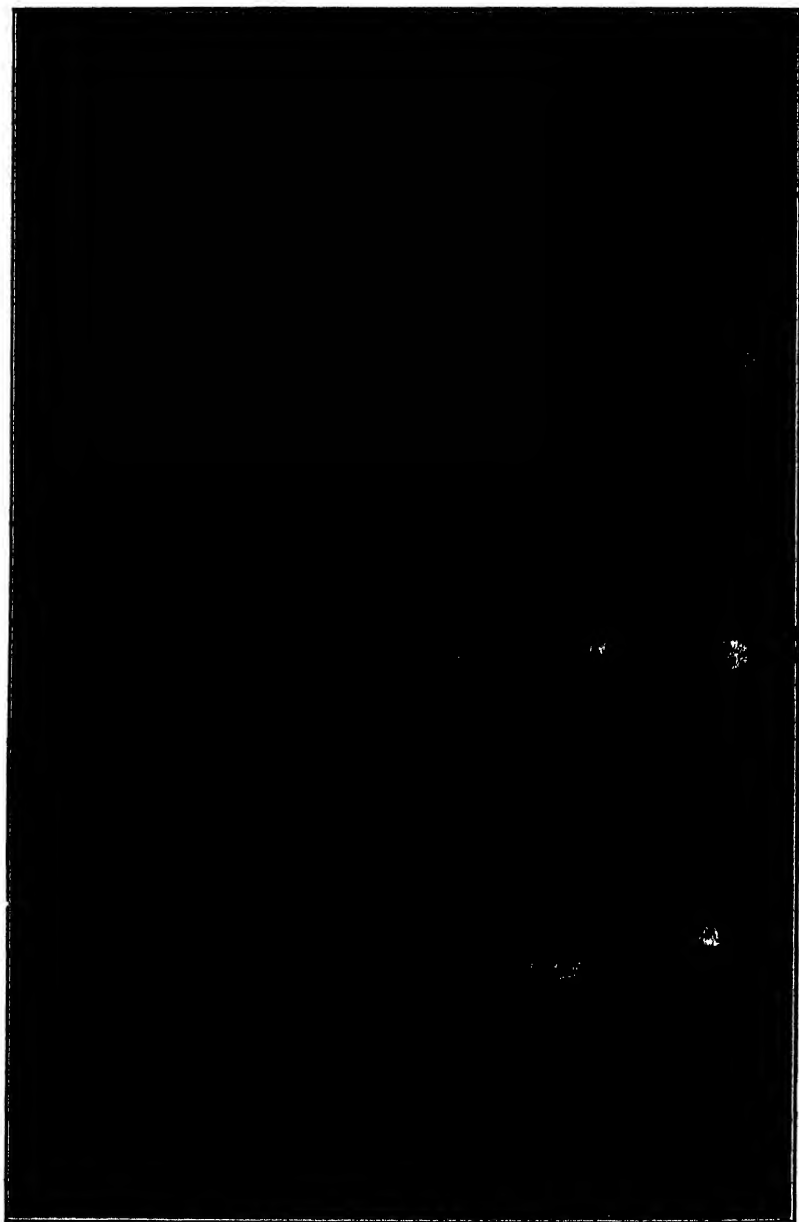


FIG. 1. *Tylostoma poculatum*  $\times 1$ .

Long and David J. Stouffer, September 11, 1941, 9688 Type (7 plants).

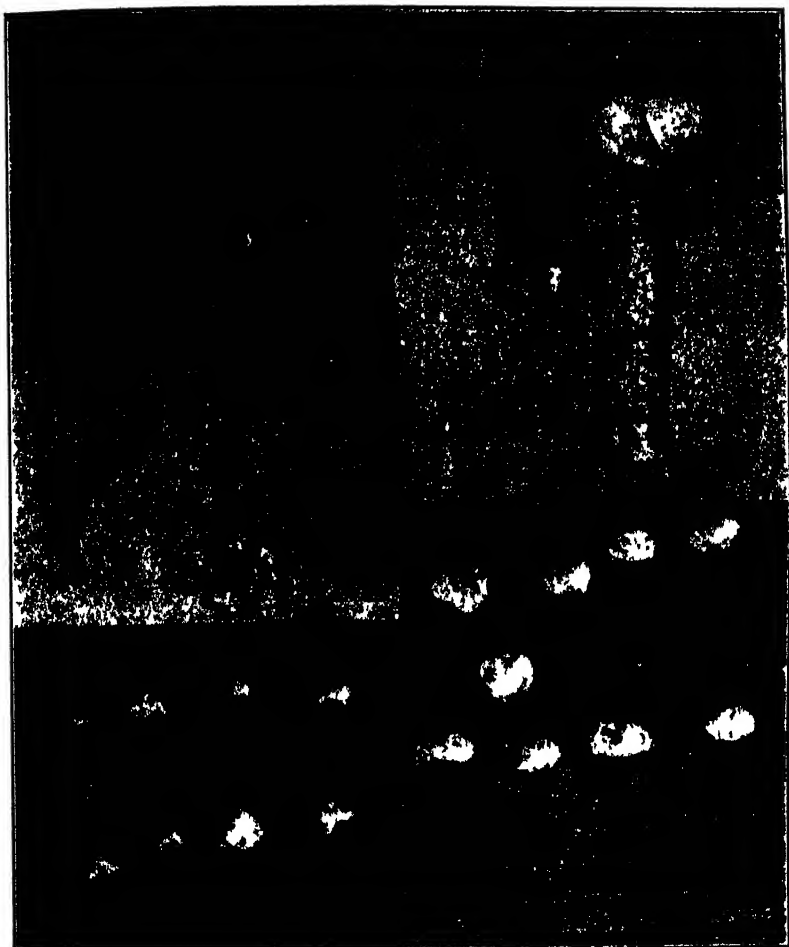


FIG. 2. *Tylostoma Lloydii*; 3, *T. obscurum*—American version; 4, *T. parvissimum*; 5, *T. xerophilum* all  $\times 1$ .

***Tylostoma parvissimum* Long & Ahmad sp. nov. FIG. 4.**

*Sporophora parvissima*. *Sporocarpio* ovato usque subgloboso 5–8 mm. alto 5–10 mm. lato. *Exoperidium* membranaceo, albo, secedente. *Endoperidio* toto levi, membranaceo, albo. *Ore* indefinito, plano usque parum prominente. *Stipite* tenui, 2–10 mm. alto 1–2 mm. crasso, brunneo. *Sporis* globosis usque subglobosis, 4.2–5.4  $\mu$ . *Episporio* parum echinulato, hyalino usque parum colorato.

*Sporophore* consisting of sporocarp, stipe and radicating base. *Sporocarp* ovate to subglobose, 5–8 mm. high by 5–10 mm. in diameter, firmly attached to stem apex. *Exoperidium* strongly and permanently membranous, outer surface covered with an adnate layer of dry clay, white under clay, slowly deciduous in flakes, leaving lacerate shreds of the dried membrane on spore sac. *Peridial sheath* a band of agglutinated hyphae and clay, persistent, 2–3 mm. broad. *Endoperidium* white, smooth, tough, membranous. *Mouth* indefinite, slightly raised, becoming a small irregular ellipsoid to orbicular orifice, about 1 mm. wide, naked with no signs of fibrils. *Collar* 1–2 mm. long, conspicuous, closely clasping the stipe, covered with dried clay. *Stipe* slender, 2–10 mm. tall by 1–2 mm. thick (exclusive of root), uniform, light brown (wood brown under the layer of clay), smooth to faintly longitudinally striate. *Volva* none; *bulb* small, firm. *Radicating base* with one stout root, 4–10 mm. long. *Gleba* clay color to raw sienna. *Capillitium* hyaline, much branched, side branches much smaller, 2–6 mm. thick, lumen none, flexuous, ends of threads square, septa rare, not swollen. *Spores* globose to broadly oval, 1-guttulate in water mount, 4.2 to 5.4  $\mu$ , usual size 4.5  $\mu$ . *Episporic* hyaline to slightly fulvous, about 1  $\mu$  thick, appearing granular in water mount, but distinctly and moderately echinulate in chloral hydrate mount, also in benzoazurin mount.

**HABITAT:** in clayey soil, common on such areas; in semi-desert regions.

**DISTRIBUTION:** INDIA, Panjab Plains, Rohtak District, Rohtak. Fungi of the Panjab Plains (338). *S. Ahmad*, June 15, 1941 (10 plants), Long Herbarium 10621 Type. Herbarium Sultan Ahmad; Fungi of India (338a). *S. Ahmad*, July 1941 (6 plants) in Long Herbarium 11026. This pretty little species is characterized by the permanently membranous exoperidium, the indefinite naked mouth, the echinulate spores, its miniature stature and by its clay habitat.

#### GENERAL REMARKS

It is almost impossible to determine the earlier species of *Tylostoma* from their original descriptions and one must, therefore, examine the type or authentic material to know what the species really is. Most of the earlier descriptions are very meager and omit most of the fundamental characters necessary for determination.

Line drawings also are practically worthless for identification purposes, since they usually do not show the real characters of the species. Likewise many of the earlier photographs are so poor that they do not show the principal characters of the species, although there are some outstanding examples of good photographs of *Tylostoma*, notably those published by Lloyd.

The habitat is often a very important character of a given species. It may grow in leaf debris in deep shade as do *Tylostoma Lloydii*, *T. simulans*, and *T. pygmaeum*, where the debris is held as a ball on the base of the stem; or the species may grow in sand in open unshaded areas as is the case with most species, or rarely a species may grow in a hard-pan clay soil as for example *T. kansense*, *T. meristostoma*, and *T. parvissimum*.

I have no apologies to offer for using Color Standards (Ridgway, 1912), since I find that the real color is of much importance. The readers can then check the chart to see just what color is meant, while if I say "reddish brown," "bay brown" etc., no one can identify such colors, as each person has his own ideas as to what such colors are; you cannot have stability by using such terms. The colors of the stipe and the endoperidium for any given species are very constant and are of much help in the identification of the species.

Below I am giving the spelling used by Persoon for the 9 new species I have described in this and previous papers. I do not believe in perpetuating an error even if it was made by Persoon. However, as some authors do and insist on following and thus continuing his error, I here list my species as Persoon, this will save future name jugglers some needless trouble: *Tulostoma cretaceum*, *Tulostoma lysocephalum*, *Tulostoma opacum*, *Tulostoma involucrellum*, *Tulostoma excentricum*, *Tulostoma meristostoma*, *Tulostoma macrocephalum*, *Tulostoma parvissimum* and *Tulostoma xerophilum*.

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# FACTORS AFFECTING THE PRODUCTION OF RESISTANT SPORANGIA OF *ALLOMYCES ARBUSCULA*

RICHARD C. JONES <sup>1</sup>

(WITH 1 FIGURE)

In the life cycle of *Allomyces* the resistant sporangium has been the object of increasingly great interest, because it is in this structure, on the asexual plant, that the crucial meiotic division occurs. Sorgel (8), Kneip (7), and Barrett (1) have made detailed studies of the morphology of the resistant sporangium in connection with their studies on the life cycle. Emerson (2) carried out extensive studies upon the variations in size of the resistant sporangia on the thirty-one strains of *Allomyces* with which he worked. Hatch (4) contributed to our understanding of this critical structure by working out the details of the zoosporogenesis which occurs within its relatively heavy walls. Hatch and Jones (6) have provided some evidence on the maturation period which appears to be necessary before the resistant sporangium can produce viable zoospores. All of the workers on this fungus have shown a keen interest in the nature of the products of the resistant sporangium, and many of them have reported upon occasional departures from the usual sexual condition of these products. In spite of all of these studies, there is still a great deal which we must learn about the resistant sporangium before we can thoroughly and confidently interpret it. Our knowledge is especially incomplete with respect to the physiology and cytology of the resistant sporangium.

One of the problems with which workers on *Allomyces* have had to contend has been the uncertainty of development of viable resistant sporangia in agar cultures through the summer months. In the summer of 1939, Hatch (5) and his students were delayed in their studies by an almost total lack of resistant sporangia in

<sup>1</sup> This study was carried out at the State College of Washington, Pullman, Washington.

agar cultures grown at the Dartmouth College laboratories in Hanover, New Hampshire. In 1942, and again in 1943, the same difficulty was encountered at the State College of Washington in Pullman, Washington. Because all of these failures in development were encountered during the late spring and summer months, and because no such difficulty has ever been reported for the winter months, it appeared that the failure of the resistant sporangia to develop might be traced to some seasonal factor which was present during the summer months. An analysis of seasonal conditions at Hanover and Pullman suggested that an explanation was most likely to be found in the photoperiod, because the seasonal variation of this factor appeared greater than the seasonal variation of any other factor effective within the laboratories. Accordingly, experiments were set up for the purpose of gaining any useful information on the effect of the photoperiod upon production of resistant sporangia in agar cultures of *Allomyces*. This problem was thought to be worthwhile for a second reason: that apparently no work has been done dealing with the influence of the photoperiod on growth and reproduction with the Phycomycetes.

EXPERIMENT I. The first experiment was set up on January 28, 1944. Four series, each consisting of ten asexual cultures in maltose-peptone agar plates, were prepared. Series I was grown in total darkness throughout the day and night, except for a few seconds daily when it was examined and its growth recorded. Series II was provided with sixteen hours of complete darkness and eight hours of daylight each day. Series III was treated with eight hours of darkness and sixteen hours of light—daylight supplemented with artificial light. Series IV received continuous light—daylight during the daytime and artificial lighting at night. Series I, II, and IV were set up in the same laboratory, but series III was grown in an adjoining laboratory. Series III was cultured apart from the other series in order to take advantage of a controlled sixteen-hour light day in the second laboratory. The door between the two laboratories was kept open at all times. A thermograph provided a record of the temperature, and thermometers, placed beside each series, were checked periodically against the thermograph readings. The growth for all four series

was recorded, and at the end of the experiment all of the cultures were examined for the presence of resistant sporangia.

In series III no increase in the diameter of the colonies could be detected from the seventh to the eleventh day. The terminal seg-

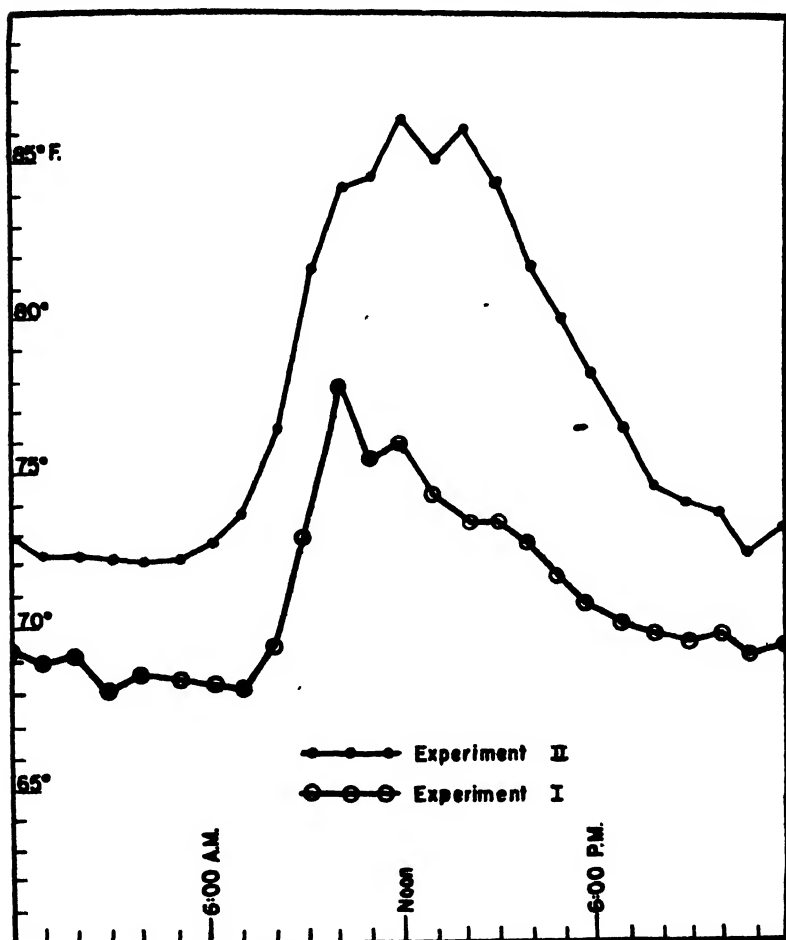


FIG. 1. Growth curves of *Allomyces arbuscula*.

ments of these hyphae had been seriously injured or killed, with a resulting plasmolysis. The new growth which had branched out behind these tips, however, appeared to have developed at a normal rate. Since series III had been placed in a different room from the other series, it was believed at the time that the factor

responsible for the interruption was probably to be found only in that room—possibly an excessively high light intensity, because the room was equipped with overhead windows, or possibly the fact that during the middle of sunny days series III experienced a slightly higher temperature than the other series.

Large numbers of resistant sporangia were produced throughout series I, II, and IV. In series III, however, although resistant sporangia developed in nearly comparable numbers up until the interruption in growth, only an occasional resistant sporangium could be found on mycelium which developed after the interruption. Moreover, although the resistant sporangia in series I, II, and IV were uniformly amber-yellow, the resistant sporangia throughout series III appeared to be of a paler color than those in any of the other series. Just what significance can be attributed to these observations it is difficult to say. Although photoperiod may have been a factor it is entirely possible that the differences in light intensity and/or temperature may also have exerted some influence.

**EXPERIMENT II.** In order to clarify the results of experiment I and to further explore the interruption of growth which occurred in series III, the experiment was repeated under more carefully controlled conditions. The second experiment began on March 17, 1944.

In this second experiment all four series were set up on the same table, situated in the same room where series III of the first experiment had been grown. In order to keep the temperatures more uniform for all cultures and to guard against too intense illumination (a possible cause for the temporary interruption of growth in series III of the first experiment), the plates were shielded from the direct rays of the sun by means of a screen placed between them and the windows. All four series were examined daily and their growth was recorded as before.

The most important difference in the growth of the plants was the almost total lack of resistant sporangia in experiment II. In only one of the forty plates (a plate exposed to twenty-four hours of light) and then only in a small sector, were any resistant sporangia found.

The failure of resistant sporangia to form in the second experiment is apparently not to be attributed to light intensity, because even though the intensity of daylight did differ somewhat during the two periods, it is to be noted that resistant sporangia failed to develop in those plates which were grown in total darkness quite as completely as they did in cultures which were exposed to different periods of light. The differences in the results of the two experiments cannot be attributed to humidity, for the relative humidity must have been very closely comparable in both experiments; the same kind and quantity of medium were used in both experiments, and the cultures were carried in the same type of culture dishes. The one factor which did vary, however, was temperature.

It appeared, then, that the differences in temperature offered a possible explanation for the faster growth and the lack of resistant sporangia in the second experiment. An examination of the thermograph charts revealed that the first experiment was run under generally lower temperatures than the second. The temperatures during the entire run ranged, in the first experiment, from a minimum of 60° F. to a maximum of 93° F. In the second experiment, the temperatures reached a minimum of 64° F. and a maximum of 103° F. Since the temperature curves varied from day to day during each experiment, and because these relatively small variations appeared to have had little, if any, appreciable effect on the growth and development of the fungus (the cultures were very uniform in their day-to-day growth), a study of the temperature curves for each day, individually, would serve no useful purpose. In order to determine the difference in temperature for an average day in each experiment, the mean hourly temperatures for the whole period were computed. The results appear in table 1.

Since minimum and maximum temperatures for each day did not always fall upon the same hour or, indeed, exactly upon any hour, the average daily minimum and maximum temperatures are here presented separately at the bottom of table 1. In experiment I, the average daily minimum was 67.5° F.; the average daily maximum was 80.3° F. In experiment II, the average daily minimum was 69.6° F.; the average daily maximum was 86.1° F.

If a temperature curve is now plotted for each experiment, based on the average hourly readings, and the two curves are drawn on the same graph, there results the condition illustrated in figure 1. It can be noted there that not only are the average hourly temperatures of the second experiment consistently higher than the

TABLE 1  
AVERAGE HOURLY TEMPERATURE  
(in Degrees Fahrenheit)

Hour	Experiment I	Experiment II
1:00 A.M.	69.2	72.3
2:00	69.3	72.4
3:00	68.3	72.4
4:00	68.8	72.2
5:00	68.6	72.2
6:00	68.6	72.4
7:00	68.4	73.5
8:00	69.5	76.2
9:00	73.4	81.5
10:00	78.1	84.3
11:00	75.4	84.6
12:00	76.0	86.4
1:00 P.M.	74.3	85.1
2:00	73.7	86.0
3:00	73.5	84.4
4:00	73.1	81.7
5:00	72.1	80.2
6:00	71.0	78.2
7:00	70.5	76.4
8:00	70.1	74.5
9:00	69.1	74.1
10:00	70.0	73.8
11:00	69.5	72.6
12:00	69.5	73.0
Average daily minimum	67.5	69.6
Average daily maximum	80.3	86.4

corresponding values in the first experiment, but the duration of the midday elevation is considerably longer, the proportion of relatively high temperatures being greater as a result of this condition. This, of course, reflects the fact that the sun's heat warmed the room for a longer period in late March than it did in late January and early February. It should be clearly evident that the total amount of heat to which the cultures of the second experiment were subjected was much greater than the amount experienced by the cultures in the first experiment. In summarization, therefore, it may be said that experiment II differed in its temperature relationships from experiment I in that the temperature attained a higher minimum and a higher maximum, that the warm

part of the day was relatively longer, and that the aggregate heat experienced by the cultures was much greater.

It cannot be said that because the minimum and maximum temperatures of any one day in the first experiment were above those of any single day in the second experiment, the minimum and maximum values are not critical. Such a conclusion would be unwarranted because although conditions might inhibit the formation of resistant sporangia on any single day, these structures might develop in the same area under more favorable conditions during the next two or three days. This is possible because resistant sporangia may continue to form for at least four days after the laying down of new vegetative growth. This fact is substantiated by the observation that in growing cultures, produced under normal conditions, resistant sporangia are known to be progressively more numerous as one proceeds from the outer perimeter of a colony inward through the four-day-old growth.

It appears, then, that in the culturing of *Allomyces arbusculus* higher temperatures, at least those within the range of these experiments, are not as conducive to the development of resistant sporangia as are the lower temperatures. What still remains to be established, however, is whether the failure of the cultures in the second experiment to develop resistant sporangia was due to the higher minimum temperature in that experiment, the higher maximum temperature, the longer period of relative high temperature, or the shorter duration of relatively low temperature. The fluctuation in the daily temperature was ruled out as a possible explanation of this problem because Hatch (3) observed in his work on zonation, that resistant sporangia developed regularly, even when the daily fluctuation in temperature did not exceed  $0.5^{\circ}\text{C}$ .

EXPERIMENT III. When the results of the two experiments were known, a third experiment was set up in order to learn whether the minimum and/or maximum temperatures which had occurred in the first two experiments were important factors in the development, or failure of development, of resistant sporangia.

Maltose-peptone agar cultures were prepared as before and placed in a constant temperature apparatus. One such apparatus was maintained at  $71^{\circ}\text{F}$ . The reason for selecting this tempera-



ture was to determine whether resistant sporangia would form at a constant (and therefore average minimum) temperature of 71° F. If resistant sporangia could be produced at an average minimum temperature of 71° F., then their failure to develop in experiment II (where the average minimum temperature was 69.6° F.) could not be attributed to an excessively high minimum temperature.

A second constant temperature apparatus was maintained at a temperature of 79° F. This temperature was selected in order to determine whether resistant sporangia would form at this relatively high constant (and therefore average maximum) temperature. If resistant sporangia should fail to develop at the average maximum temperature of 79° F., after having developed in experiment I (where the average maximum temperature was 80.3° F.), then failure to develop here could not be attributed to an excessively high maximum temperature.

Four sets of asexual cultures were set up as follows: Series I was grown at 71° F. throughout the experiment. Series II was subjected to 71° F. for sixteen hours of each day but was maintained at 79° F. for the other eight hours. Series III was exposed to 79° F. for sixteen hours of each day and to 71° F. for the remaining eight hours. Series IV was carried in the 79° F. temperature throughout the experiment. All cultures were grown at the same time, on the same batch of medium, and in total darkness.

The most significant results were those which concerned the production of resistant sporangia. On the same day in which experiment III was discontinued, all of the cultures were examined for the presence of resistant sporangia. Every plate was found to contain considerable numbers of these structures. However, series I (grown at 71° F.) seemed to have produced a comparatively heavy yield of these thick-walled bodies. This was especially noticeable when series I was compared with series IV which exhibited a relatively sparse distribution. In order to obtain comparative figures on the relative numbers of resistant sporangia in each series, counts were taken from representative plates.

The method used in making counts of resistant sporangia follows. From series I and IV, four plates each were chosen; from series II and III, two plates each were chosen. All plates were selected on the basis of their general healthy appearance. Each

plate was then placed on the stage of a microscope under a 10 mm. objective and the resistant sporangia within a single field were counted. Counts of this sort were made for ten different fields in each plate, and the average number of resistant sporangia per field was computed for each culture. At least two fields were selected from each quarter-segment of any given plate, in order to obtain figures which would be, as nearly as possible, representative of the plate as a whole. Care was also taken to select all fields from within the line marking four-day-old mycelium so that the resistant sporangia would have approximately attained their maximum number in each area studied. Aside from these two precautions all fields were chosen at random. The figures representing all counts appear in table 2.

TABLE 2

Series	Number of resistant sporangia											Plate average	Average for series
I 24 hrs. at 71	Plate 1	63	81	59	74	77	69	75	72	75	79	72.4	72.27
	Plate 2	80	78	66	71	75	78	70	69	72	78	73.6	
	Plate 3	70	74	79	64	63	72	78	72	63	68	70.3	
	Plate 4	78	69	72	76	68	75	72	66	75	77	72.8	
II 16 hrs. at 71 8 hrs. at 79	Plate 1	53	71	49	65	67	58	55	63	65	52	59.8	58.9
	Plate 2	56	63	51	53	54	59	64	62	60	59	58.1	
III 8 hrs. at 71 16 hrs. at 79	Plate 1	39	42	40	48	43	45	40	45	47	45	43.4	43.75
	Plate 2	36	45	48	42	49	49	51	43	38	40	44.1	
IV 24 hrs. at 79	Plate 1	39	40	36	40	51	32	36	40	41	38	39.3	38.25
	Plate 2	34	42	38	36	38	35	40	39	42	41	38.5	
	Plate 3	41	39	32	37	36	36	34	42	41	36	37.4	
	Plate 4	36	42	38	33	41	39	37	38	35	39	37.8	

*Effect of high and low temperatures.* An analysis of table 2 shows that more resistant sporangia were formed in series I (71° F.) than in series IV (79° F.), confirming our previous observations that lower temperatures are more favorable for the development of resistant sporangia.

*Effect of minimum temperature.* It should be noted that series I formed more resistant sporangia than did series II, and that series II produced more resistant sporangia than series III. This fact is significant because all three of these series had the same

minimum temperature (71° F.). It can therefore be stated with reasonable confidence that the differences in the number of resistant sporangia could not have resulted from differences in the absolute minimum temperatures. Moreover, since 71° F. is above the average minimum temperature which prevailed in experiment II, it appears likely that the failure of resistant sporangia to form in that experiment had not been due to an excessively high minimum temperature.

*Effect of maximum temperature.* A comparison of the figures obtained for series II, III, and IV reveals that series II produced more resistant sporangia than did series III, and that series III produced more resistant sporangia than series IV. When it is considered that all three of these series possessed the same maximum temperature (79° F.), it may be concluded that this gradual decline in the production of resistant sporangia could not have been caused by an excessively high maximum temperature. Since some resistant sporangia formed in series IV, it still cannot be definitely concluded that the failure of resistant sporangia to form in experiment II could not have been due in part to an excessively high maximum temperature. However, these experiments make it appear highly improbable that maximum temperature was effective to any great degree.

PERIODICITY OF HIGH AND LOW TEMPERATURE. A further examination of the figures for series I, II, and III shows a positive relationship between the increase in duration of the cool part of the day and the increase in number of resistant sporangia produced. Likewise, a comparison of the figures for series II, III, and IV reveals a gradual decrease in the number of resistant sporangia as the warm part of the day was lengthened. We may conclude that where these temperatures are concerned, a relatively long duration of low temperature tends to favor the production of resistant sporangia; or, conversely, that a relatively long duration of high temperature tends to limit the production of resistant sporangia.

EFFECT OF AGGREGATE TEMPERATURE.<sup>2</sup> A computation of the aggregate temperatures, to which each series in experiment III was subjected, shows that there is an inverse relationship between tem-

<sup>2</sup> Degree hours: number of hours times temperature in degrees F.

perature and production of resistant sporangia. Arranged in tabular form these figures are presented in table 3. It may be concluded, then, that aggregate temperature is an important factor in determining the number of resistant sporangia produced in maltose-peptone agar cultures.

TABLE 3

Series	Temperature in degree-hours per day (24 hours)	Average number of resistant sporangia
I 71° F.—24 hrs.	1704	72.27
II 71° F.—16 hrs. 79° F.— 8 hrs.	1768	58.90
III 71° F.— 8 hrs. 79° F.—16 hrs.	1832	43.75
IV 79° F.—24 hrs.	1896	38.25

It now seems possible to conclude that temperature is an important controlling factor in the production of resistant sporangia in cultures of *Allomyces arbusculus* grown on maltose-peptone agar, and that, within certain limits, the total amount of temperature to which cultures are subjected is of more significance than minimum temperatures, maximum temperatures, or degrees of fluctuation.

The results of the foregoing experiments suggest high aggregate temperature as a principal factor responsible for the frequent failures of resistant sporangia to form during the summer months.

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## TWO NEW CHYTRID PARASITES OF CHYTRIOMYCES

JOHN S. KARLING

(WITH 1 FIGURE)

During the course of a study of an isolate of *Chytriomyces hyalinus* Karling (5) the sporangia of this chitinophyllic fungus became heavily infected with two other chytrids. The first of these parasites to be reported here relates to the eucarpic, rhizidiaceous genus *Rhizophyidium*. It occurred first in great abundance on a pure culture of *C. hyalinus* which was growing on purified shrimp chitin, but later a few of its thalli were found on *C. aureus* also. In view of the latter discovery, inoculation tests were made at once to determine whether or not this fungus will infect other chitinophyllic chytrids. Heavily infected sporangia of *C. hyalinus* were repeatedly introduced into cultures of *Asterophlyctis sarcoptoides*, *Siphonaria variabilis*, *Obelidium mucronatum*, *Chytriomyces appendiculatus*, *Rhizophlyctis petersenii*, *Polychytrium aggregatum*, and *Rhizidium* sp., but none of these chytrids became infected. Likewise, cultures of *Achlya flagellata*, *Saprolegnia ferax*, *Aphanomyces* sp., and various species of *Pythium* were inoculated in the same manner, but no infection occurred. These results suggest that the parasite may be limited in host range to two species of *Chytriomyces*. It is significant to note that it has not infected *C. appendiculatus*, another chitinophyllic species of *Chytriomyces* from Virginia and Connecticut.

So far only six, or possibly seven, *Rhizophyidium* parasites of other fungi have been reported: *R. carpophilum* on various aquatic Oomycetes (Zopf, 12, and others), *R. (Mastigochytrium) Saccardiae* on the ascocarps of *Saccardia Durantae* (Lagerheim, 6), *R. Pythii* on *Pythium complens* (de Wildeman, 10), *R. fungicolum* on the hyphae of *Gloeosporium* (Zimmerman, 11), *R. pollinis* on conidia of *Sclerospora graminicola* (Müller, 8) and oospores of *Albugo bliti* (Melhus, 7), *R. parasitans* on *Rhizophyidium gonio-*

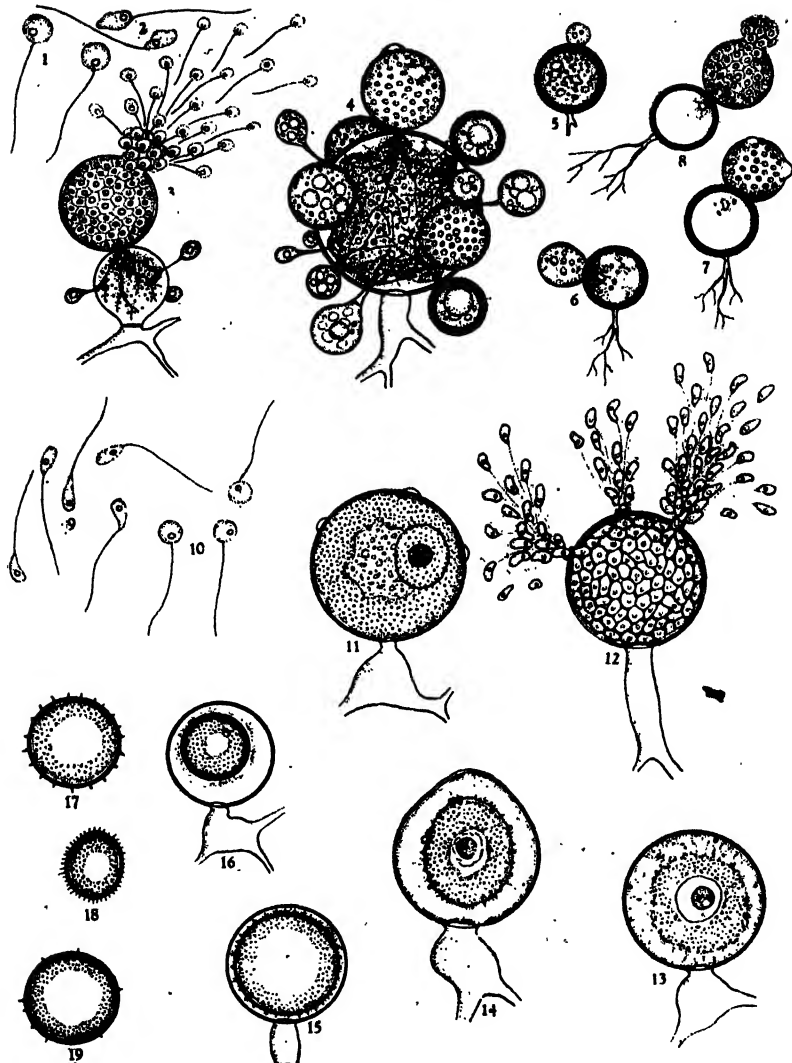


FIG. 1-8. *Rhizophydium Chytridiomycii*. FIG. 9-19. *Rozella Chytridiomycii*. 1, 2, free swimming and amoeboid zoospores; 3, emergence of zoospore, parasite's sporangium larger than that of host; 4, sporangium of *C. hyalinus* infected with eleven sporangia in various stages of development and two mature resting spores; 5-8, stages in germination of the resting spores; 9, free swimming resting spores; 10, zoospores immediately after coming to rest; 11, parasitized sporangium with three exit papillae, large central vacuole, and enlarged primary nucleus of host; 12, emergence of zoospores simultaneously from three exit papillae; 13, early stage of resting spore

*sporum* (Scherffel, 9), and *R. chytriphagum* on *Phlyctochytrium Aureliae* (Ajello, 1). Of the six, only *R. carpophilum* and *R. chytriphagum* are well known. Furthermore, it is not certain that the species reported by Müller and Melhus relates to *R. pollinis*. The sizes of the zoospores, sporangia, and resting spores are unknown for *R. Pythii*; resting spores are unknown for *R. Saccardiae* and *R. fungicolum*, and rhizoids are unknown in *R. parasitans*. Therefore, it is impossible to make extensive comparisons on morphological grounds between these species and the one on *Chytriomycetes*. Except for *R. chytriphagum*, the zoospores of the *Chytriomycetes* parasite are considerably smaller than those of the other species for which the spores have been observed. Although the parasites of *Chytriomycetes* and *R. chytriphagum* have similar zoospores and resting spores, they differ markedly in the character of the rhizoids, and for this reason they are regarded as different species. Also, the fact that the parasite of *Chytriomycetes* did not infect *Achlya*, *Saprolegnia*, *Aphanomyces*, and *Pythium* indicates that it has a different host range from those of *R. carpophilum* and *R. Pythii*. On these as well as on morphological grounds, we feel warranted in regarding it as a distinct species for which the name *R. Chytriomycii* is proposed.

The life cycle and developmental stages of *R. Chytriomycii* are shown in figures 1 to 8, and inasmuch as they do not differ markedly from those of other *Rhizophyidium* species, it is unnecessary to describe them in detail. At least, no striking differences have been observed which warrant special attention. It may be noted, however, that the zoospores often germinate at considerable distances from the host cell with the result that the sporangia are often stalked (FIG. 3). Also, no evidence of sexuality has been seen in relation to resting spore development.

### ***Rhizophyidium Chytriomycii* sp. nov.**

Fungus parasiticus. Thallo numerosiis. Sporangii hyalinis, laevibus, sessilis aut caulis, sphericis, 8-30  $\mu$ , cum 1-3 papillis exeuntibus. Zoosporae

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development, host nucleus in central vacuole; 14, later stage of development, host nucleus disintegrating; 15, mature echinulate resting spore which almost fills the host sporangium; 16, small smooth-walled resting spore; 17-19 resting spores freed by disintegration of host sporangium, showing variations in degree of echinulation.



hyalinis, sphaericis, 2-2.8  $\mu$ . Sporis perdurantibus laevibus, sphericis, 7-18  $\mu$ , pariete fuscis; germinantes ut prosperangia, parte interiori emergente ut zoosporangio membranum tenui ad superficiem sporae.

Thalli usually numerous, up to 20 on one host sporangium. Sporangia hyaline, smooth, sessile or stalked, spherical, 8-30  $\mu$ , with one to three exit papillae. Rhizoidal system finely branched, main axis up to 3  $\mu$  in diameter. Zoospores hyaline, spherical, 2-2.8  $\mu$ , with a minute, .5-.8  $\mu$ , hyaline refractive globule. Resting spores dark brown, spherical, 7-18  $\mu$ , with one or more large refractive globules; functioning as a prosperangium in germination.

Parasitic on *Chytriumyces hyalinus* and *C. aureus*, Candlewood Lake, Conn.

The second parasite found in *Chytriumyces* occurred intramatically and relates to the genus *Rosella* of the family Olpidiaceae. It appears to be an obligate parasite which is limited in host range to *C. hyalinus*. All attempts to infect *C. aureus*, *C. appendiculatus*, *Obelidium mucronatum*, *Asterophlyctis sarcopoides*, *Siphonaria variabilis*, *Rhizidiomyces hirsutus*, *Rhizophydium Chytriumycii*, *Rhizophlyctis petersenii*, *Nowakowskiella elegans*, and *Rhizidium* sp., with it have failed. Likewise, *Aphanomyces* sp., *Achlya flagellata*, *Saprolegnia ferax*, *Pythium andrdrum*, *P. irregulare*, *P. splendens*, *P. ultimum*, *P. debaryanum*, *P. vexans*, *P. aphanidermatum*, *P. oligandrum*, *P. helicoides*, *P. graminicolum*, *P. aristosporum*, *P. acanthicum*, *P. tardicrescens*, and several unidentified species of *Pythium* have not become infected. Although these inoculation attempts do not include all of the hosts of the fourteen reported monosporangiate species of *Rosella* (see Karling, 2, 3, 4), they nevertheless delimit this species from *R. Rhizophlyctii*, *R. Cladochytrii*, *R. irregularis*, and possibly *R. laevis*, *R. Endochytrii*, *R. cuculus*, and *R. Rhizophydii* as far as hosts are concerned.

Insofar as they are now known, most described monosporangiate species of *Rosella* are very similar in type of development, size, shape, and behavior of the zoospores, as well as in the color, size, shape, and echinulation of the resting spores. The parasite in *C. hyalinus* does not differ markedly in these characteristics from the other species, and it is therefore difficult to distinguish it sharply on morphological grounds. Unlike *R. Monoblepharidis*,

*R. Rhipidii*, *R. Apodyae*, *R. irregularis*, *R. laevis*, *R. cuculus*, *R. Blastocladiac*, *R. Polyphagi*, *R. Cladochytrii*, and *R. Endochytrii*, it does not cause hypertrophy of the host cell. In this respect it is similar to *R. Rhizophlyctii* and *R. Rhizophydii*. However, it does not infect the host of *R. Rhizophlyctii* and has slightly smaller zoospores than *R. Rhizophydii*. For these reasons we shall regard it as a distinct species under the name of *Rozella Chytriomycii* until further studies on this genus have proven it to be otherwise. At the same time, we realize fully that it, as well as many of the other *Rozella* parasites which have been described as valid species, may prove to be a physiological variety with a limited host range.

As is shown in figures 9 to 19, the development and life cycle of *R. Chytriomycii* are so similar to those of other monosporangiate species that very little can be added to the accounts already given. Although the parasite does not cause perceptible hypertrophy and distortion of the host cell, the primary host nucleus nevertheless becomes enlarged. In normal healthy thalli of the host, the primary nucleus does not divide until the sporangium is almost mature in size. Consequently, it becomes quite large and may be readily seen in the living condition as a hyaline, optically homogeneous, oval to spherical body with a large nucleole. In infected sporangia, the nucleus may appear even larger and often lies within or adjacent to a large central vacuole (FIG. 11). Such nuclei have never been observed to divide, and it may be assumed that the presence of the parasite prevents mitosis in addition to causing hypertrophy of the host nucleus. In several developmental stages of the resting spores (FIGS. 13, 14) the primary host nucleus was observed in the central vacuole, and by the time the spore wall was formed very little of the nucleus except the membrane and nucleole was visible (FIG. 14).

### ***Rozella Chytriomycii* sp. nov.**

Fungus parasiticus; sporangia solitariis, longitudinem latitudinemque cellae matricialis in toto complementibus, sphericis, 10–40  $\mu$ , cum 1–3 papillis; pariete sporangiorum ex cella matricali fere non discernendo. Zoosporiis hyalinis, clavatis aut oblongatis,  $3 \times 1.5 \mu$ , se in sporangio torquentibus antequam emergunt; natantibus emicantim, raro amoeboides. Sporibus perdurantibus, ovalibus, sphericis, 7–20  $\mu$  diametro, cum maxima gutta centrica et protoplasmate crasse granuloso; pariete fusco, spiculoso, raro laeve; germinatione non visa.

Sporangia solitary, hyaline, filling host cell and conforming with the latter in size and shape, usually spherical, 10–40  $\mu$ , with one to three exit papillae; wall of sporangium usually indistinguishable from that of host cell. Zoospores hyaline, oblong or slightly clavate,  $3 \times 1.5 \mu$ , with a minute, .5–.7  $\mu$ , refractive globule; swirling in sporangium before emerging; darting about rapidly in swimming, rarely becoming amoeboid. Resting spores partly or almost completely filling host cell, oval or spherical, 7–20  $\mu$ , with large central vacuole, and coarsely granular cytoplasm; wall dark brown, rarely smooth, usually spiny or echinulate; germination unknown.

Parasitic in *C. hyalinus*, Candlewood Lake, Conn.

#### SUMMARY

*Rhizophydium Chytriomycii* and *Rozella Chytriomycii* are two new chytrid parasites which occur on and in the sporangia of *Chytriomycetes*. The first parasite attacks *C. hyalinus* and *C. aureus*, while the second one is limited in host range to *C. hyalinus*. Extensive attempts to inoculate numerous other chytrids and larger fungi with these parasites have failed.

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## A NEW SPECIES OF MYXOMYCETES

TRAVIS E. BROOKS

Three collections of an apparently undescribed species of *Perichaena* were made in Kansas on decaying leaves in August 1940. Later additional material was found while examining leaves collected in 1938 for *Physarum megalosporum* Macbr. A determined effort to find this species in the same area where the *P. megalosporum* had been found, and in several other Kansas localities, has yielded a number of excellent collections.

### ***Perichaena syncarpon* sp. nov.**

Sporangiis sessilibus, sparsis vel stipatis, pulvinatis vel applanatis, 0.05–0.8 mm. latis, fulvo-brunneis, rufo-brunneis, vel nigris. Membrana exteriori cartilaginosa, firma, granulosa, in lobatis dehiscentis; interiori vix discreta, tenellula. Capillitio parce evoluto, cum vix ramosis tubis cavis. Sporidis pallide luteis, subglobosis, spinulosis inaequalibus, 4–16 coalitis, 10–12  $\mu$  crassis. In foliis putrescentibus.

Plasmodia watery to opaque tan, ochraceous, or pinkish, sometimes somewhat opalescent, irregularly circular or oblong in outline, somewhat rugose, up to about 2 mm. across. Sclerotia minute, orange. Sporangia scattered, gregarious, crowded, or forming aethalia up to 2 mm. across, sessile on a broad base, pulvinate to applanate, often hemispherical or subglobose, sometimes forming short, straight or curved plasmodiocarps, circular in outline or polygonal from mutual pressure, yellowish-brown, reddish-brown, to black, often with a black margin, 0.05–0.8 mm. diam. Sporangium wall of two layers; the outer layer cartilaginous, firm, opaque, thickened with included deposits of dark granular matter, dehiscing into lobes along more or less prominent ridges, or dehiscing irregularly; the inner layer closely adhering to the outer, usually inconspicuous, membranous, pale yellow, transparent, sometimes somewhat iridescent, without deposits of refuse matter. Capillitium scanty, attached to the sporangium wall, consisting of sparingly branched yellow threads marked with minute, irregular, close-set constrictions and minute warts, 2–3.5  $\mu$  diam. Spores in mass golden yellow, pale yellow by transmitted light, adhering in clusters of 4–16, spinulose, more strongly spinulose on the outer surface as they lie in the cluster, 10–12  $\mu$  diam.

On decaying leaves of boxelder, catalpa, cottonwood, elm, giant ragweed, hackberry, and sunflower which have accumulated under

shrubby or under dense associations of shrubby, herbaceous plants, and grasses. Kansas; T. E. B. 495, Geary Co., Aug. 21, 1938; T. E. B. 681, Riley Co., Aug. 19, 1940; T. E. B. 734, Saline Co., Aug. 22, 1940; T. E. B. 760, Edwards Co., Aug. 4, 1940; T. E. B. 907, Geary Co., Aug. 2, 1944; T. E. B. 920, Geary Co., July 2, 1945 (Type collection); T. E. B. 928, Geary Co., July 4, 1945; T. E. B. 930, Douglas Co., July 7, 1945; T. E. B. 933, Douglas Co., July 14, 1945; T. E. B. 934, Douglas Co., July 19, 1945; T. E. B. 936, Geary Co., July 21, 1945; T. E. B. 946, Geary Co., Aug. 19, 1945; T. E. B. 948, Geary Co., Aug. 19, 1945. All above collections were made by the writer. The frequency with which this species has been collected would indicate that it is not uncommon. Portions of the type collection have been distributed to the Mycological Collections of the United States Bureau of Plant Industry, Beltsville, Maryland, the Farlow Herbarium, Harvard University, Cambridge, Massachusetts, the Herbarium of Kansas State College, Manhattan, Kansas, the Herbarium of the New York Botanical Garden, New York, New York, the Herbarium of the State University of Iowa, Iowa City, Iowa, the Herbarium of the British Museum, London, England, and to Charles Meylan, St. Croix, Switzerland.

*Perichaena syncarpon* is readily distinguished from all previously described species of *Perichaena* particularly by the adherence of the spores in clusters. In the clustering of spores and the tendency to form aethalia this species shows a close affinity to *Minakatella longifila* G. Lister. It differs, however, in the definitely perichaenoid capillitium. Apparently *P. syncarpon* is intermediate between the species of *Perichaena* and *M. longifila*. This latter species is represented by a single collection of four small colonies or aethalia from Japan. Miss Lister (A Monograph of the Mycetozoa. Third edition, revised by Gulielma Lister. 1925) suggests that *Minakatella* has some affinity with *Perichaena*, but differs in the aethalioid habit and the smooth capillitium. The establishment of a species of *Perichaena* often having an aethalioid habit tends to support her idea.

The inconspicuousness of this species, its habitat on decaying leaves, and the possibility of a restricted distribution may account for the lack of previous collections. The material from Edwards, Riley, and Saline Counties was found beneath bushes on the under

surface of leaves in contact with the soil, and consists, for the most part, of colonies of crowded sporangia and aethalia. In other collections the habitat was apparently more favorable for the retention of moisture. The fruitings, consisting to a greater extent of distinct, scattered sporangia, were found abundantly on the surface of and within the leaf mat.

Sclerotia were found in abundance on leaves of 930 from Douglas Co. The day after the leaves were rewetted numerous small plasmodia were noted. These plasmodia were relatively inactive in that they moved about very slowly, and did not possess the back and forth flow of protoplasm characteristic of most plasmodia. Sclerotia have since been found in several of the collections. Plasmodia observed in the field have generally been pinkish or tan in color.

As is usual with most slime molds considerable variation occurs in this species. Although distinct sporangia, as well as those in colonies or aethalia, are generally pulvinate to applanate, small scattered sporangia are sometimes hemispherical or subglobose on a broad base, or rarely subglobose on a narrow base. Where sporangia are in contact the sporangium walls are often incompletely developed. Occasionally in aethalia the only vestige of these sporangium walls may be a single wall jutting toward the center of the aethalium from the margin, or a bar at the center of the aethalium extending from the base to the top. Sometimes sporangia or aethalia are depressed at the center. In several of the collections many of the smaller sporangia are shiny yellow with a very thin, transparent, yellowish sporangium wall through which the spore balls can readily be seen, due to the absence of refuse matter. Typically present are the raised lines along which the sporangium wall dehisces into lobes. Sometimes, especially in smaller sporangia, these dehiscence lines are weakly developed, or completely lacking. The capillitium has been scanty in all the material studied thus far. In smaller sporangia the capillitium is often completely lacking.

The writer is grateful to Mr. Robert Hagelstein, Dr. J. C. Gilman, and to Dr. Frank C. Gates for helpful suggestions and criticisms made during the preparation of this paper.

## NOTES AND BRIEF ARTICLES

### WANTED

As a result of wartime losses, certain numbers of MYCOLOGIA have become exhausted. Among these are Volume 32, issue 1, and Volume 33, issue 2. Two dollars each will be paid for any copies of the above numbers.

FRED J. SEAVER,  
Managing Editor

### NOTES ON FLORIDA FUNGI

**GOMPHIDIUS FOLIIPORUS** Murrill. Singer's treatment of this species in Farlowia (2: 280) for July, 1945, is difficult to understand. Those of my readers who have received specimens from me can see at a glance that it is perfectly distinct from *Phylloporus rhodoxanthus* (Schw.) Bres. and, moreover, it is not a bolete at all.

In my species the cap is pale-reddish-fulvous; context pallid, becoming slightly bluish when cut; gills pallid, dark-blue when bruised, at length dark-brown; spores umbrinous in mass. See Mycologia 35: 432. 1943, for full description. In my notes I stated that it was placed in *Gomphidius* only temporarily.

II. *P. rhodoxanthus* the cap is reddish-yellow-brown to chestnut-brown; context yellowish, not bluing; gills deep-yellow, not bluing; spores yellowish in mass. Good descriptions are given by Atkinson, Kauffman and others.

How Singer can call my species simply a geographical race of *P. rhodoxanthus* is beyond me. Even when *G. foliiporus* turns a beautiful blue when wounded he waves it aside as of no special consequence. Not so, however, when he is describing *Gyrodon proximus* as distinct from *B. meruloides*.

**BOLETUS FLAVIMARGINATUS** Murrill. In Farlowia (2: 293) for July, 1945, Dr. Singer makes this species a synonym of *B. illudens* Pk. As I look at the two types on the table before me I cannot resist a smile at Dr. Singer's expense, and I believe he



would smile with me if he were here. The differences are so marked that even a small child could recognize them.

In my species the cap is reddish-fulvous, somewhat viscid; tubes bright-yellow, becoming greenish with age; spores about  $14 \times 4-5 \mu$ ; stipe smooth or delicately reticulate above. See *Mycolegia* 31: 110. 1939.

In Peck's species the cap is typically yellowish-brown, dry; tubes not so bright-yellow and soon becoming darker; spores about  $11 \times 4.5 \mu$ ; stipe coarsely reticulate, usually entirely to the base. See *Rep. N. Y. State Mus.* 50: 108. 1897. Coker's pl. 35 shows the coarsely reticulated stipe very well. See *Boletaceae of N. C.* by Coker and Beers.

*GYROPORUS ROSEIALBUS* Murrill. In *Farlowia* for July, 1945, Singer makes this species a synonym of my *G. subalbellus*, described in 1910 from Ocean Springs, Miss. With the types of the two species on the table before me, I maintain that they are distinct and have essentially the characters assigned to them in the original descriptions, although I now know much more about the beautiful *G. roseialbus* than I did at first. It is common about Gainesville, where I have found specimens 10 cm. broad with stems 8 cm. tall and 4 cm. thick. Average hymenophores are considerably smaller, but all are rosy-white when young. The spores in both species are as originally described, those of *G. subalbellus* being ovoid and about  $7 \times 4.5 \mu$ , while those of *G. roseialbus* are oblong-ellipsoid and  $11-13 \times 4-5 \mu$ .—W. A. MURRILL.

GAINESVILLE, FLA.

ANNUAL MEETINGS: They will be held in conjunction with the A.A.A.S. meetings at St. Louis, Missouri, March 27-30, 1946





ROBERT HAGEI STEIN, 1870-1945

# MYCOLOGIA

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## ROBERT HAGELSTEIN

1870-1945

LATE HONORARY CURATOR OF MYXOMYCETES, NEW YORK  
BOTANICAL GARDEN

JOSEPH F. BURKE

(WITH PORTRAIT)

A review of the life-work of Robert Hagelstein may be treated in three phases. The first—an active business career—commenced in early manhood, culminated in voluntary retirement in middle life from the management of a successful mercantile concern, to pursue for twenty years full-time scientific studies. This business career yielded the competence that permitted him freedom to devote his full time to the second and third phases, respectively his studies of the diatoms and of the myxomycetes.

It is interesting to recall from personal observation during years of association, the effect of business training in his approach to scientific study. A well developed habit of work was evident to all who came in contact with him. He had retired not to relax, though many business men find in scientific pursuits a relaxation from the stress of business. Rather, he retired to start a new career in which he set himself objectives that were pursued on a schedule as rigid as any in business. In business he constantly dealt with figures whereby he acquired a mathematical ability that enabled him to solve rapidly and mentally all of his microscopical

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measurements. More than in anything else his business training was noticeable in the action of his mind in dealing with intricate problems, requiring the sorting and evaluating of facts to arrive at sound conclusions. This ability was reflected not only in his taxonomic work but in his participation in the administration of the affairs of scientific societies.

His interest in science was practically lifelong. Minerals early held his attention. Soon he shifted to the microscope and microscopical biology. Association with the Department of Microscopy of the Brooklyn Institute of Arts and Sciences specialized further his pursuits along these lines and broadened his acquaintanceship with others scientifically minded. With the decline of the Department of Microscopy, he and many of his associates transferred their activities to the ranks of the New York Microscopical Society and greatly assisted in the resurgence of the Society at the time of the First World War. In 1921 he became its Vice-President and in 1923 and 1924 served as President. Not long after came his retirement from business. Science ceased to be an avocation and became a full time occupation.

For some years the diatoms had been foremost in his microscopical studies and he was rapidly accumulating an outstanding collection of diatom slides.<sup>1</sup> He had been interested particularly in the diatoms of Long Island and had collected extensively in that area. However, an opportunity afforded him by Dr. Nathaniel Lord Britton to participate in the Scientific Survey of Puerto Rico and the Virgin Islands caused him to concentrate for several years on the study of the diatoms of that region with collecting trips for diatom material in the years 1926, 1928 and 1929. Further years were spent in the completion of his report and its publication was delayed during the depression until 1939.

His interest and activities in the diatoms ran concurrently, for a number of years, with a developing and growing interest in the myxomycetes. At first, a few short papers were published, commencing in 1927, including one describing two new species. By 1935, after he had finished his diatom manuscript and devoted six months of continuous work to the indexing of his large collection of diatom slides, he was able to concentrate fully on the myxomy-

<sup>1</sup> Journal of The New York Botanical Garden 41: 278. December, 1940.

cetes. As with the diatoms, his early study centered mostly on the myxomycetes of Long Island, with some collecting in Puerto Rico and other islands. In 1936 his "Critical Study of the Mycetozoa of Long Island" appeared and there followed over a period of years a numbered series of "Notes on the Mycetozoa." With the growing abundance of observations entering into these "Notes," he decided to make available to students of this group of organisms, an orderly summary of his years of study into which he had put the best of his energies and critical ability. Happily in 1944 he saw this summary take the form of his book, "The Mycetozoa of North America, based upon the specimens in the Herbarium of The New York Botanical Garden." This was the culmination of the third and final phase of his life-work. There he stated frankly his opinions based on keen and conscientious observation, presented with full pride in that this voluntarily imposed task had been discharged to the best of his ability.

Apart from, but having its association with his scientific research, was his curatorship of the myxomycete collections of The New York Botanical Garden. Here again his early-formed habit of work was a force that carried him through a complete survey of the collections, not once but several times, with detailed microscopical study of sporangia and spores of the specimens. In addition the entire collection received full and personal attention as to labelling, boxing, and arrangement. Following his appointment in 1930, more than fifteen years found him working on these collections, of which ten years were devoted to the myxomycetes alone.

Though he devoted long hours of work to the myxomycetes in his laboratory at home and at the Botanical Garden, he also spent extended periods on tour, collecting from Quebec to Florida and in the islands of the West Indies south to Trinidad. His first years of intensive collecting, on Long Island, were succeeded by equally intensive and even more experienced collecting in northeastern Pennsylvania. Of the 285 species included in his book, 269 are in the collections of The New York Botanical Garden. Of these, 216 were studied by him in the field. The remarkable collecting partnership formed early with Joseph Henri Rispaud, his constant field companion, had been of the utmost assistance to him in this work. The forays that he conducted each year in

June and September on Long Island under the auspices of The Torrey Botanical Club, in coöperation until 1940 with the New York Microscopical Society, for the purpose of introducing the myxomycetes to initiates, were occasions of inspiration to those attending.

When the Cryptogamic Herbarium of The New York Botanical Garden was installed on the third floor, a room was assigned to the groups that had held his special interest, the myxomycetes and the diatoms. In this room were placed and incorporated in the Botanical Garden collections, the results of his years of collecting of the myxomycetes. Here also he placed his large and comprehensive collection of diatoms. The room was formally opened on January 11, 1941.

Mr. Hagelstein was born in New York on May 16, 1870. Later he lived in Brooklyn and from there moved to Mineola, Long Island, a move which placed him within a few minutes' automobile ride of the famous kettle hole that for years supplied his best collecting until he started going to Pennsylvania and other more distant localities. Still within easy distance of his well loved collecting spot he passed away at Mineola on October 20, 1945.

His scientific affiliations were The New York Botanical Garden, the Mycological Society of America, in whose annual forays he took a very active part, The New York Microscopical Society, Torrey Botanical Club, New York Academy of Sciences, American Microscopical Society, Royal Microscopical Society, and Queckett Microscopical Club.

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# THREE NEW ZOÖPAGACEAE SUBSISTING ON SOIL AMOEBAE

CHARLES DRECHSLER<sup>1</sup>

(WITH 6 FIGURES)

Three additional members of the family Zoöpagaceae have recently come to light in Petri plate cultures in which miscellaneous microörganisms introduced with decaying plant material were given prolonged opportunity to develop on maizemeal-agar medium overgrown with *Pythium* mycelium. All three forms were found subsisting on amoebae, one of them attacking the animals after the manner of an endoparasite, through germination of ingested spores, while the other two attack in a predaceous manner, by capturing the protozoans through adhesion to mycelial hyphae. Apart from descriptions of these new species, supplementary comment is herein supplied relative to an amoeba-capturing form I presented earlier under the binomial *Stylopaga rhabdospora* (3: 374-377).

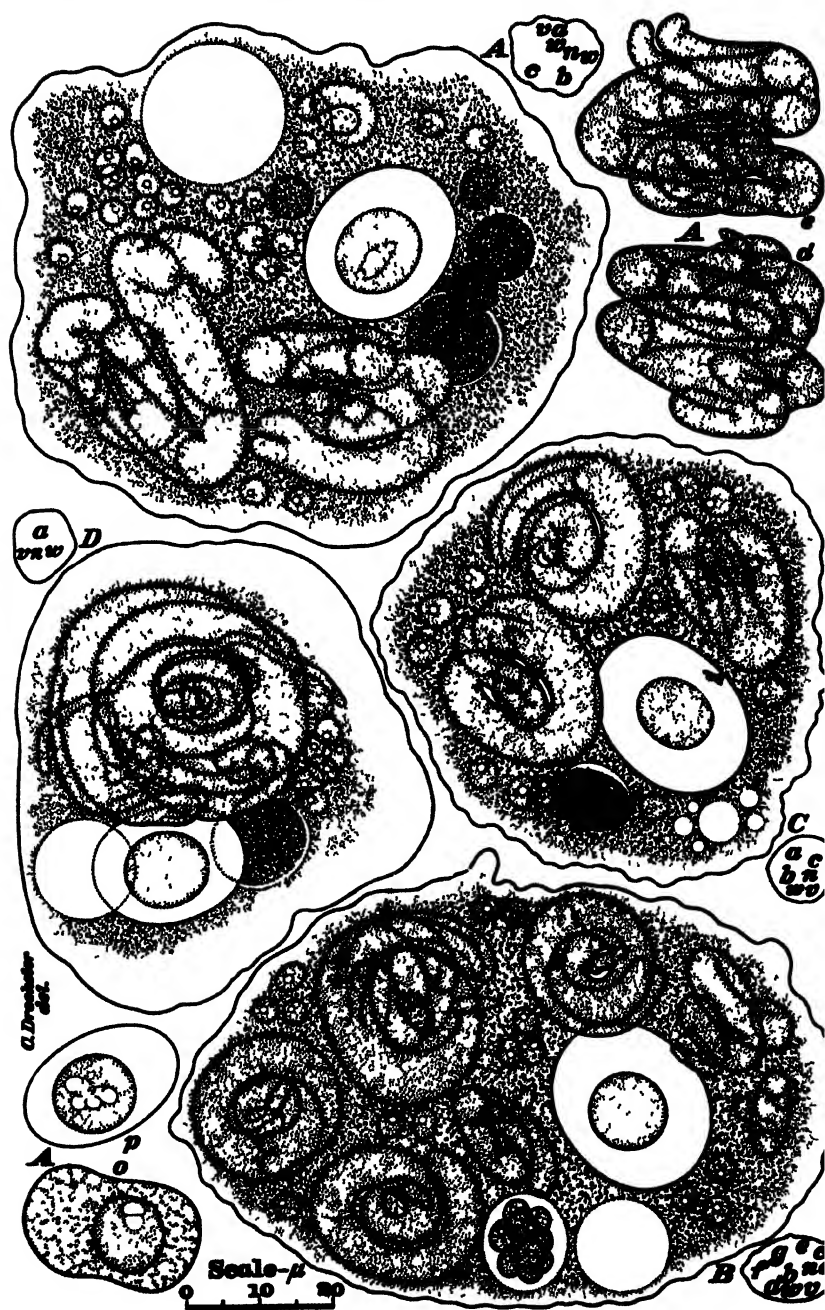
## A SPECIES OF COCHLONEMA PRODUCING WARTY AZYGOSPORES

The new endoparasitic fungus made its appearance in many maizemeal-agar plate cultures that after being permeated with mycelium of *Pythium arrhenomanes* Drechsl. had been further planted with small quantities of friable vegetable detritus consisting mainly of partly decayed cucumber (*Cucumis sativus* L.) leaves and partly decayed lilac (*Syringa* sp.) leaves. The particular lot of vegetable detritus here in question was gathered near Greeley, Colorado, in October 1944, and has received mention in an earlier paper (9) as a source of the nematode-capturing basidiomycetous form I described under the binomial *Nematoctonus haptocladus*. Often, indeed, the amoeba parasite was found developing abundantly in the same cultures with *N. haptocladus*, its presence being betrayed

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by scattered aerial tufts of ascending conidial chains readily detectable to microscopical examination carried out with a dry objective. As under such examination the sporiferous tufts closely resembled those of both *Cochlonema symplocum* Drechsl. (6: 258-266) and *C. euryblastum* Drechsl. (7: 283-289), closer scrutiny was necessary to determine whether one of these species or possibly some allied form was active here in destruction of animal life. Accordingly, portions of the cultures were removed and examined under a water-immersion objective of high magnification. Though the conidiiferous tufts disintegrated badly in the moist preparations, they clearly had their origin in parasitized amoebae referable manifestly to a single species which in normal condition, as also in the earlier stages of attack, varied in diameter between 60 and 100  $\mu$  when drawn into a rounded shape (FIG. 1, A-C; FIG. 2, A, B; FIG. 3, A). Its firm, thickish pellicle, cast into broadly undulating or more delicately rippled folds, surrounded a colorless, somewhat dispersedly granular sarcode within which could be distinguished a single prolate ellipsoidal nucleus, 20 to 25  $\mu$  long and 13 to 20  $\mu$  wide, that contained normally a slightly darker, globose or prolate central body, about 8 to 11  $\mu$  wide (FIG. 1, A-D, n; FIG. 2, B, n; FIG. 3, A, n; FIG. 4, A, n). The animal endured infection with much fortitude, continuing its pseudopodial locomotion and the operation of its contractile vacuole (FIG. 1, A-D, v; FIG. 2, A-B, v; FIG. 3, A, v) until most of its contents were expropriated. Often its cytoplasm revealed a variable number of digestive vacuoles which sometimes were filled with massed bacteria (FIG. 1, A, w; C, w; D, w; FIG. 3, A, w-z) and sometimes contained a clump of spores (FIG. 1, B, w) belonging evidently to a mucoraceous fungus; such ingested spores being, however, more usually found imbedded individually here and there in the sarcode, without noticeable vacuolar development (FIG. 1, A-D; FIG. 3, B; FIG. 4, A). From its morphology the animal was assigned to *Amoeba verrucosa* Ehrenb.—to the same species, therefore, earlier found preyed upon by *Dactylella tylopaga* Drechsl. (2) and parasitized both by *C. megalosomum* Drechsl. (4: 128-137) and by *C. symplocum*.

As has been intimated, attack on the animal is always found initiated by germination of ingested conidia; the individual spore,

FIG. 1 *Cochlonema agatum*

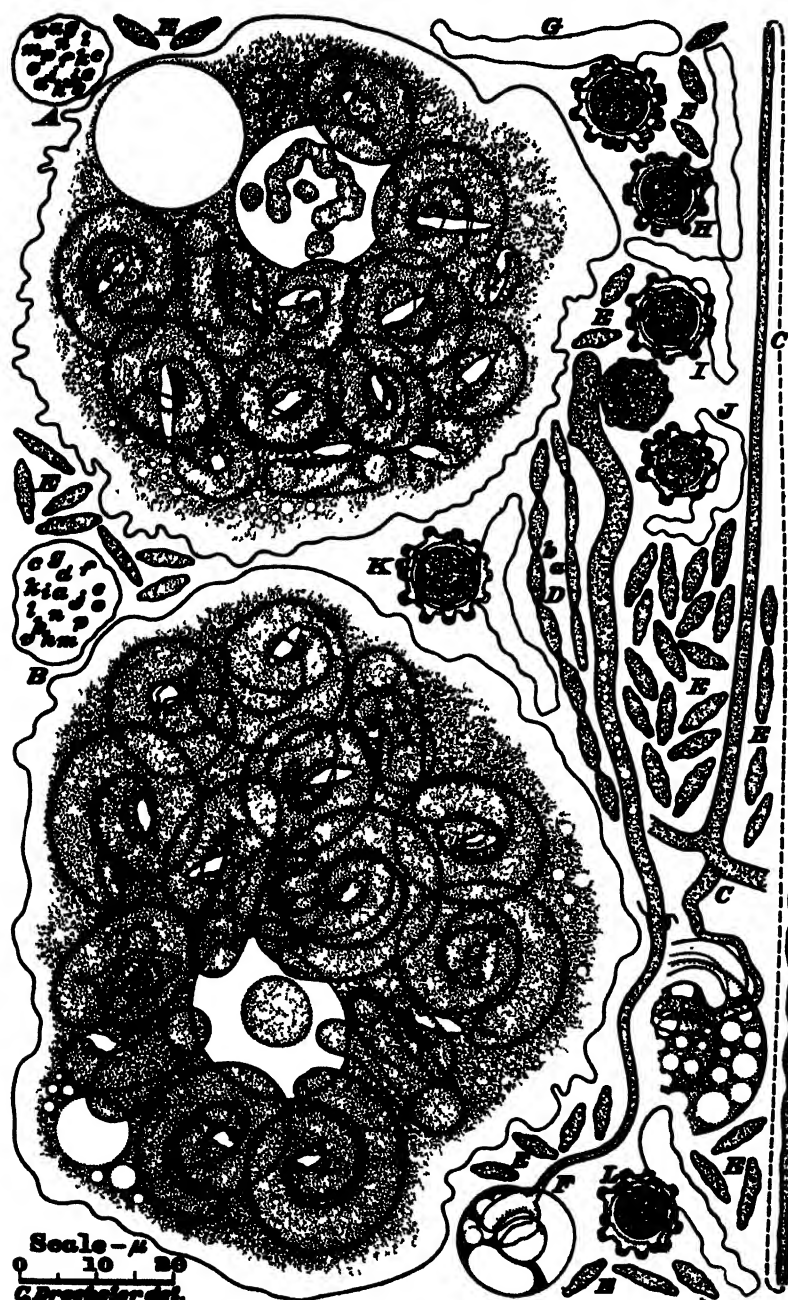
soon after its ingestion, giving rise somewhat obliquely from one of its ends to a germ tube, which then prolongs itself into a thallus by feeding on the ambient host cytoplasm. In respect to the manner of establishing itself, the fungus thus shows general parallelism with *Cochlonema symplocum* and *C. curyblastum* rather than with *C. megalosomum*. Despite this parallelism and the similarity of host relationship, the young growing thallus is soon distinguishable from correspondingly young thalli of *C. symplocum* not alone by reason of its noticeably greater proximal width but also by reason of its more strongly flaring conformation (FIG. 1, *A*, *a*; FIG. 2, *A*, *a-d*); though on the other hand, it shows generally no close approach to the very stout proximal attachment and abrupt widening so conspicuous in the thallus of *C. curyblastum*. A strong tendency toward curvature becomes manifest early, and soon leads to a somewhat snail-like coiling which because of its geometrical regularity appears much more suggestive of *C. curyblastum* than of *C. symplocum*. The thallus maintains its unbranched condition during a rather extended period of elongation (FIG. 1, *B*, *a-d*; FIG. 2, *A*, *d-m*, *o*; *B*, *a-i*), but after describing  $1\frac{1}{2}$  to 2 spiral turns it usually bifurcates a first time (FIG. 1, *B*, *e*, *f*; *C*, *a-c*; FIG. 2, *A*, *p*; *B*, *j-m*, *o*, *p*); a second dichotomy taking place after growth of the two branches has augmented the coil in some instances by a half turn (FIG. 1, *A*, *b*, *c*) and in other instances by only one-tenth of a turn (FIG. 1, *B*, *g*). Where the four branches resulting from a second dichotomy have opportunity for substantial elongation, a third dichotomy often ensues (FIG. 1, *A*, *d*, *e*; *D*, *a*); this being followed, under appropriate conditions, by a fourth dichotomy in some, if not in all, of the terminal elements (FIG. 3, *A*, *a*; *B*). The thalli with three or four successive bifurcations usually have a volume in a general way commensurate with the number (8 to 16) of their terminal branches; for although the tertiary and quaternary branches are for the most part too narrow and too short to contribute much bulk in themselves, their production is accompanied usually by rather marked increase in width (and possibly also in length) of the proximal trunk as well as of the primary and secondary branches.

Since the eventual size of a thallus is determined by the quantity of host protoplasm available for assimilation, maximum dimensions

are attained especially in instances where only a single thallus is present in an individual animal (FIG. 1, *D*; FIG. 3, *A*, *B*). Such instances of unitary infection are not infrequent when the fungus first begins its development in a culture. Later, as conidia become strewn about more and more abundantly, they are ingested in increasing numbers, with the result that many animals will then be found harboring more than a dozen thalli (FIG. 2, *A*, *B*); and the eventual size of the thalli will be reduced proportionately.

Regardless of whether one or several conidia have been engulfed, growth of the parasite for a considerable period seems to work no injury on the animal other than progressive reduction of its cytoplasmic contents. Usually the cytoplasm will have been reduced to about a quarter of its original volume before the nucleus begins to look abnormal either from excessive vacuolization of the central body or from mottling of the peripheral layer. There is reason to believe that under suitable circumstances an animal host can recover as long as nuclear degeneration has not gone beyond an incipient stage. After the drawing reproduced in figure 1, *A*, had been prepared, the infected amoeba shown therein was kept under observation 6 hours longer at a temperature close to 23° C. During these 6 hours all three of the thalli (FIG. 1, *A*, *a-c*) within the animal continued growing actively, so that the host cytoplasm, already reduced to about one-half of its original mass when observations were begun, suffered further reduction to about one-fourth or one-fifth of its original mass, while the outer layer of the nucleus became rather conspicuously mottled (FIG. 1, *A*, *o*). The preparation was then stored overnight at a temperature of 15° C. Evidently the lower temperature greatly benefited the amoeba, for 16 hours later its contractile vacuole was again operating briskly, and the outer layer of its nucleus again presented a clear homogeneous appearance (FIG. 1, *A*, *p*). The thalli of the parasite, on the other hand, had not only failed to continue growing, but gave evidence of debility in a noticeably vacuolated condition of their contents.

Where no environmental change intervenes in behalf of the infected amoeba its dwindling sarcodine sooner or later becomes incapable of further locomotion. Thereupon the fungus promptly puts forth reproductive filaments even though the host nucleus (FIG. 1, *D*, *n*) may yet present a normal appearance; so that the

FIG. 2. *Cochlonema agamum*

final stages in the extinction of the animal's life and in the expropriation of its contents are accomplished simultaneously with the earlier stages in the reproduction of the parasite. The filaments growing from the thalli are scarcely half as wide as those of *Cochlonema euryblastum*. Generally the smaller thalli, including unbranched and once-dichotomous specimens together with some twice-dichotomous specimens, will put forth only a single reproductive filament, usually from a position on the convex side 3 to 10  $\mu$  from the parent conidium (FIG. 2, *F*; FIG. 3, *C*, *a*, *b*, *c*, *e*, *f*; FIG. 4, *A*, *a-e*). Some thalli of greater size, with 2, 3, or 4 successive bifurcations, will put forth two reproductive filaments (FIG. 1, *D*, *a*; FIG. 3, *C*, *d*, *g*; *D*, *a*, *b*), the second one arising beyond the first and often about a half turn from the origin of the coiled structure. Thalli of still larger size are found provided with three reproductive filaments (FIG. 3, *B*, *a-c*); the third one arising from a position a quarter turn beyond the second. The presence in one observed instance of an additional outgrowth (FIG. 3, *B*, *d*) suggests that the largest thalli may, perhaps, at times give rise to four reproductive hyphae.

When an infected animal succumbs on the surface of an agar culture held under ordinary conditions of storage—right side up, and with exposure to weak or moderate illumination mainly from above—all the reproductive filaments invariably make their way to the ceiling of the host pellicle. The direction of their growth is evidently not governed by chance, for where the coils of the parent thallus or of some other thallus are in the way, as is frequently the case, the filaments take a circuitous course around the interposed structures (FIG. 3, *D*, *a*, *b*; FIG. 4, *A*, *b*). They soon push out through the ceiling of the pellicle, and after widening rather markedly, extend a few procumbent branches over the upper surface of the amoeba. Where reproduction is exclusively asexual these branches do not attain any considerable length; yet since they are usually present in some number and are concentrated in a rather small area on top of the animal, they become intermingled into a loose overlying meshwork (FIG. 3, *C*). From the meshwork is sent up a tuft of 15 to 25 conidiiferous hyphae (FIG. 3, *C*, *h-s*) similar to the aerial tufts whereby the fungus was first detected; the individual reproductive filament contributing usually two or

three conidiiferous hyphae, though if the parent thallus is small (FIG. 3, C, a) it may supply only one such hypha (FIG. 3, C, h).

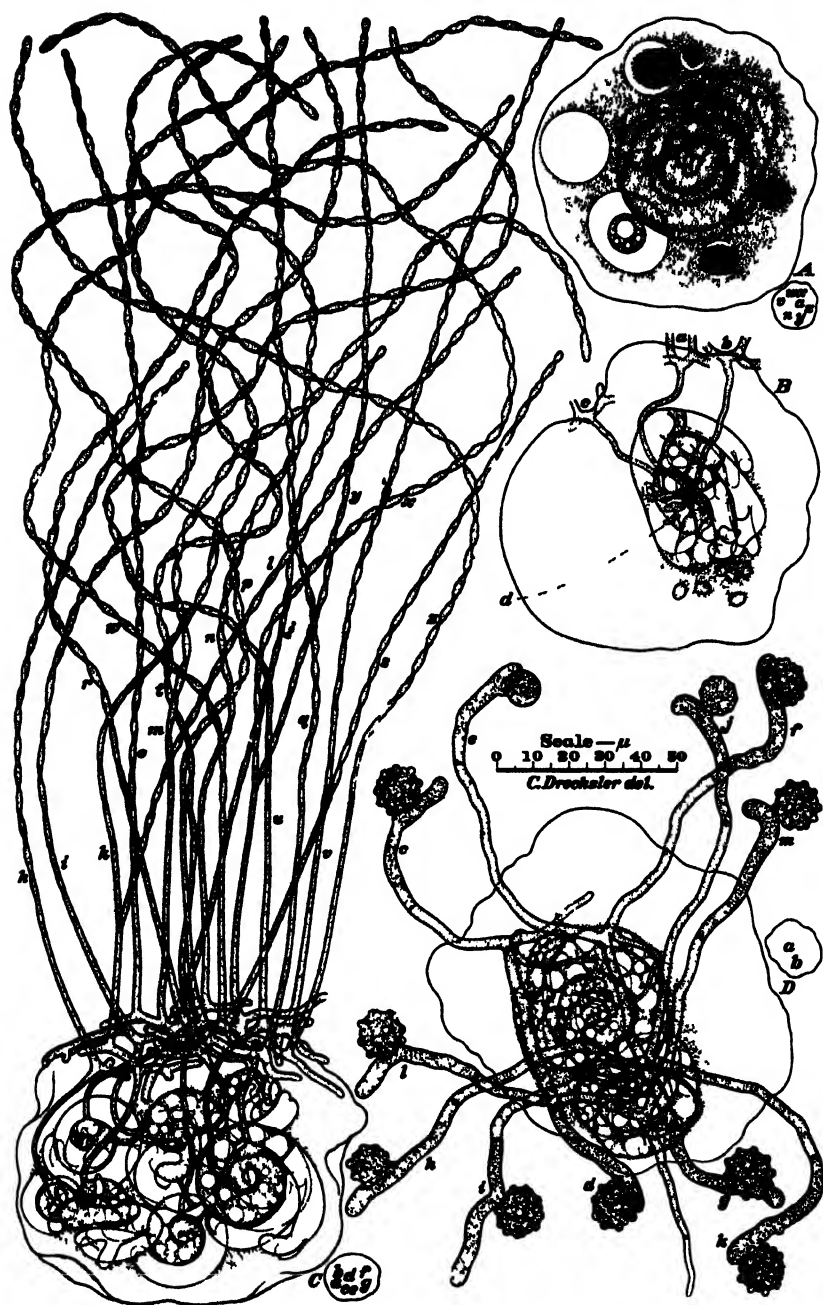
In its proximal portion the conidiiferous hypha shows no special modification, but beginning at a height of 25 to 100  $\mu$  constrictions appear together with minute warty irregularities (FIG. 2, C). Thence upward for a distance of about 50  $\mu$  the constrictions become progressively more pronounced and occur at diminishing intervals, while concomitantly the warty irregularities become more numerous and somewhat more prominent. Beyond the transitional region of increasing modification the hypha is prolonged with constrictions at equal intervals and with equal display of warty sculpturing (FIG. 2, C; FIG. 3, C, h, j, o, q, s, v). After the hypha has attained definitive length, its modified portion is converted into a conidial chain through evacuation of contents from the middle of each constriction, followed by deposition of a wall at both ends of each empty isthmus (FIG. 3, C, i, m, n, p, r, t, u, z); the number of spores delimited in a chain varying commonly between 25 and 65. An aerial filament that has given rise to one chain (FIG. 3, C, k, x) may grow out below the proximal conidium to produce a second sporogenous hyphal element (FIG. 3, C, l, y). Such successive development would seem more frequent where very large thalli are concerned in reproduction than with thalli of moderate size, and, of course, is wholly absent where a thallus is too small to produce more than a single conidial chain. As might be expected, the several lowermost conidia originating from the transitional portion of an aerial hypha are longer, narrower, and smoother (FIG. 2, D, a) than the generality of their fellows that come from the more distal, better differentiated hyphal portions (FIG. 2, D, b). On slight disturbance the mature conidial chains break up, leaving the disarticulated spores (FIG. 2, E) strewn about on the substratum ready to be ingested by any specimen of *Amoeba verrucosa* visiting the seeded area. In size and shape the conidia differ little from those of *Cochlonema symplocum*.

When an infected animal succumbs in a submerged position the reproductive hyphae, after pushing through the host pellicle, find their way to the surface of the substratum by rather widely divergent paths; wherefore the aerial conidial apparatus produced by them is not aggregated in a luxuriant tuft but is dispersed over an



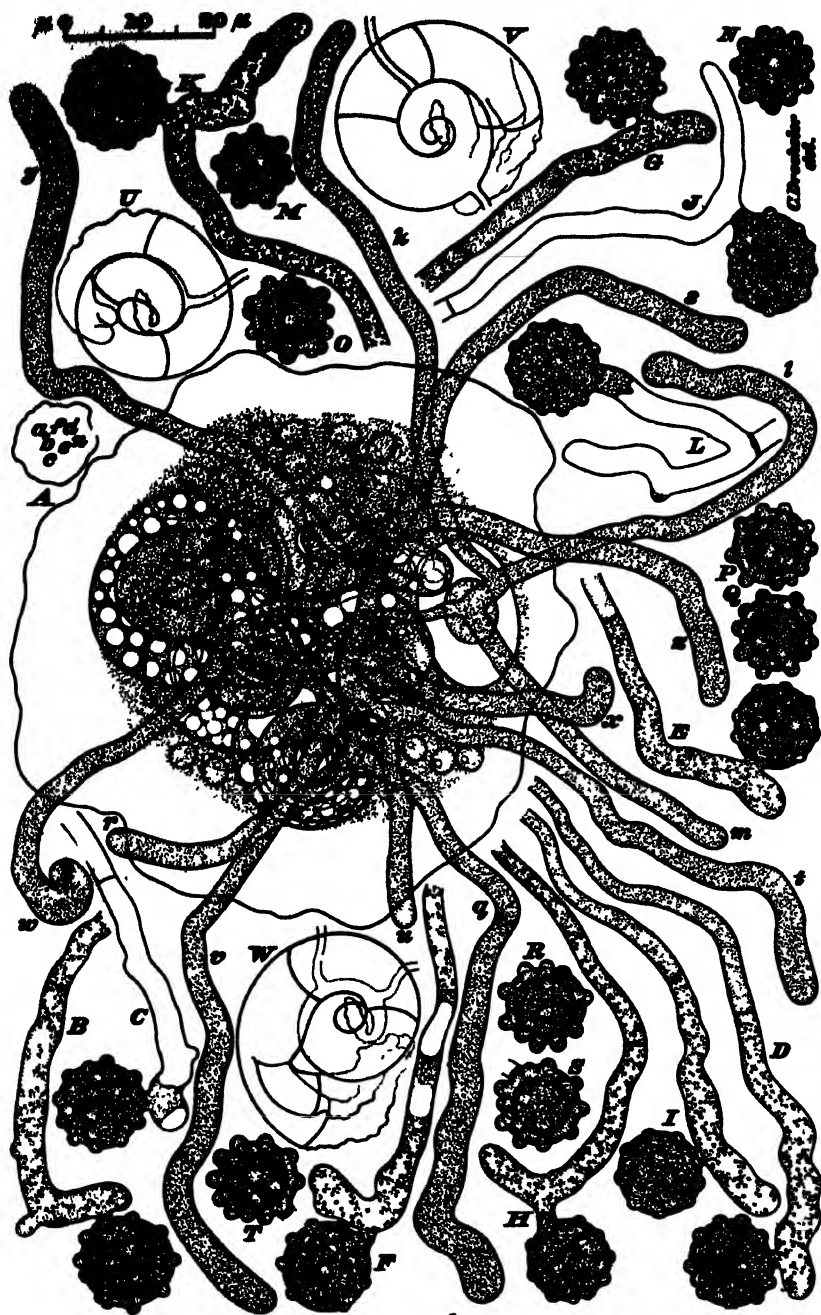
extensive area as multiple floccules, each composed of 1 to 3 conidial chains. Such scattered sporulation presumably corresponds no less truly to the normal development of the fungus than tufted sporulation. What would seem, in contrast, to represent thoroughly abnormal behavior is often observable when reproductive filaments are put forth from thalli that are undergoing microscopical examination; for these filaments then consistently make their way to the floor rather than to the ceiling of the host pellicle. Manifestly this curious misdirection of growth results from positive phototropic response to the wholly unnatural upward illumination usual with vertical microscopes. As similar perversion has been noted frequently in congeneric forms, all development of reproductive filaments taking place from thalli directly under microscopical observation should be mistrusted.

Apart from asexual reproduction by conidia the fungus shows an equivalent of sexual reproduction in its frequently abundant formation of azygospores. While, as in related fungi, lower temperatures seem in some degree to favor development of the more durable spores, the two types of reproduction are often closely associated; both conidia and azygospores originating not only from the same animal host, but from the same thallus and even from the same reproductive filament. In instances where an infected amoeba has succumbed on the surface of the substratum azygospore development is initiated, like conidial formation, by extension from the thalli (FIG. 4, *A*, *a-c*) of reproductive filaments that make their way to the upper part of the animal, and then push out through the ceiling of the pellicle, to give rise, after widening rather markedly, to a few (2, 3, or 4) stout prostrate branches (FIG. 4, *A*, *k-m*, *q-s*); or if the thallus is of small size the reproductive filament may continue growth without branching (FIG. 2, *F*). The prostrate branches or prolongations grow out, often somewhat crookedly, to a length of 50 to 125  $\mu$ , and thus come to extend some distance into the material underlying or surrounding the animal. Through continued gradual widening they acquire typically an elongated clavate shape. A cross-wall is now laid down usually about 40  $\mu$  from the tip. The terminal cell thereby delimited soon burgeons forth a globose body laterally; the new excrescence more often arising from a position near the tip of the cell, or between the

FIG. 3. *Cochlonema agatum*

middle and the tip (FIG. 2, *F*; FIG. 3, *D*, *c-h*, *j-m*; FIG. 4, *B-J*), than from a position at or slightly below the middle (FIG. 3, *D*, *i*; FIG. 4, *K*). Terminal development of the globose body, either on the tip of the cell (FIG. 4, *L*) or on a recognizable stalk of lateral origin (FIG. 4, *H*), would seem, like branching of the cell (FIG. 4, *K*, *L*), to occur as a departure from the usual. Although the distal cell here is larger than the young gametangia of most Zoöpagaceae whose sexual reproduction has been observed, it probably receives a considerable quantity of protoplasm from below after its delimitation; for, as a rule, when the distal cell has contributed all its contents to the globose body, the proximal portion of the branch similarly appears empty (FIG. 4, *C*, *J*, *L*). In the later stages of its growth the globose body becomes beset with prominent verrucose protuberances. At maturity these protuberances seem largely filled with material of a consistency uniform with the thickened peripheral wall from which they arise (FIG. 2, *G-L*). Often the peripheral wall appears spatially separated from an approximately equally thick membrane surrounding the spherical living protoplast within (FIG. 2, *G-L*); though often, again, the separateness of layers is very indistinct, and the appearance offered is more nearly that of a spherical protoplast surrounded by a thick, homogeneous, yellowish, verrucose wall (FIG. 4, *M-T*). The protoplast is evidently composed, in large part, of densely granular material. Further details regarding its internal make-up could not be ascertained because of the serious optical difficulties resulting from the presence of the numerous protuberances.

The boldly sculptured globose bodies, or azygospores, are formed in slightly submerged positions even when the protozoan host has succumbed on the surface of the substratum. In instances where the amoeba has succumbed below the surface, the zygomorphic branches, unlike the reproductive filaments concerned in asexual reproduction, show no special tendency to grow upward, but produce their spores rather indiscriminately all around the animal and at no great distance from the pellicle. Once the animal's contents have been nearly exhausted, the migration of fungous protoplasm necessary to sustain continued development of azygospores, or of conidia, entails progressive evacuation of the thalli—a process accompanied here, as in several congeneric forms, by deposition of

FIG. 4. *Cochlonema agamum*

retaining walls (FIG. 2, *F*; FIG. 3, *B*; *C*, *a-g*). Usually only a single transverse wall will be formed in a small thallus, while eight partitions may be laid down in a large one. Empty thalli of moderate size frequently contain three or four cross-walls (FIG. 4, *U-W*). After some time the empty thallic envelopes, beginning in the distal portion, progressively collapse and evanesce; and when the host pellicle likewise disappears only a cluster of 10 to 35 azygospores remains as evidence of the animal's destruction.

The absence of conjugation in the development of its more durable reproductive bodies distinguishes the fungus most decisively from *Cochlonema symplocum*. Since similar reproduction is not known to occur elsewhere in the genus, except possibly in the optically difficult species I described earlier as *C. pumilum* (5: 398-402; 8: 9-14), an epithet meaning "unmarried" may be appropriately suggestive.

### *Cochlonema agarum* sp. nov.

Hyphae assumptentes ex tubo germinationis circa  $1\ \mu$  crasso in modum cornus latescentes, incoloratae, primo continuatae,  $4-13\ \mu$  crassae, usque  $175\ \mu$  longae, in spiram cochleatim semel vel bis vel subinde paene ter volutae, nunc simplices nunc semel usque quater dichotomae, prope originem ex latere convexo 1-3 fortasse rarius 4 hyphas genitabiles emittentes; hyphis genitabilibus  $1-1.5\ \mu$  crassis, animali debilitato vel moribundo pelliculam ejus saepe praecipue in parte superiore perforantibus, denique nunc ex aliquot ramis brevibus ( $1-30\ \mu$  longis) procumbentibus 1-4 hyphas conidiiferas in aerem emittentibus nunc 1-4 hyphas azygosporiteras in materiam subjacentem vel ambientem proferentibus. Hyphae conidiiferae incoloratae, erectae vel ascendentes, sursum in catenulas 25-65 conidiorum abeuntes, quandoque ex apice partis inferioris sterilis 25-100  $\mu$  longae repullulantes, denique quoque aliam catenulam gignente; conidiis incoloratis; cylindraceis vel elongato-ellipsoideis vel fusiformibus, plerumque minute verrucosis,  $6-11\ \mu$  longis,  $1.5-2.5\ \mu$  crassis. Hyphae azygosporiferae incoloratae, vulgo aliquantum pravae, saepius  $50-125\ \mu$  longae, basi  $2-2.5\ \mu$  crassae, sursum leniter latescentes, apice  $3.8-5.8\ \mu$  crassae, primo continuatae mox septo in duas cellulas divisae; cellula posteriore  $33-63\ \mu$  (saepius circa  $40\ \mu$ ) longa, subinde ramosa, ex latere vulgo prope apicem subinde medio azygosporam gignente; azygospora flavida, globosa,  $9-12.5\ \mu$  (saepius circa  $10\ \mu$ ) diametro, 20-35 verrucis  $2-2.5\ \mu$  diametro ornata, globulum protoplasmatis  $6-7.5\ \mu$  diametro circumdante.

*Amoebam verrucosam* necans habitat in foliis plantarum (*Cucumeris sativi*, *Syringae* sp.) putrescentibus prope Greeley, Colorado.

Assimilative hyphae colorless, originally continuous, arising from a germ tube about  $1\ \mu$  thick, widening out in the manner of a horn, mostly 4 to  $13\ \mu$  in greatest transverse diameter, up to  $175\ \mu$  long,

coiled in a snail-like spiral consisting of one to two and one-half turns, often simple, but when better developed bifurcate or two to four times successively dichotomous, putting forth from the convex profile near the proximal end one to three (sometimes possibly four) reproductive filaments which after disablement of the animal host push through its pellicle often mostly on the upper side, either to give rise from several short prostrate branches to aerial conidiiferous hyphae in numbers usually from one to four, or to extend one to four zygophoric branches into the underlying or surrounding material. Conidiiferous hyphae colorless, erect or ascending, at maturity terminating in a chain of 25 to 65 conidia, sometimes growing out from the tip of a sterile proximal part 25 to 100  $\mu$  long and giving rise to a second conidial chain; conidia colorless, cylindrical, elongate-ellipsoidal or spindle-shaped, nearly always minutely verrucose, mostly 6 to 11  $\mu$  long and 1.5 to 2.5  $\mu$  wide. Zygophoric branches colorless, usually somewhat crooked, commonly 50 to 125  $\mu$  long, 2 to 2.5  $\mu$  wide at the base, widening out gradually to a diameter of 3.8 to 5.8  $\mu$  near the apex, at first continuous, later divided by a cross-wall into two cells; the distal cell 33 to 63  $\mu$  (mostly about 40  $\mu$ ) long, occasionally branched, producing an azygospore laterally sometimes from a median position but much more often from a position closer to the apex; azygospores yellowish, subspherical, studded with 20 to 35 warty protuberances 2 to 2.5  $\mu$  wide, exclusive of these protuberances measuring 9 to 12.5  $\mu$  (commonly about 10  $\mu$ ) in diameter, at maturity surrounding a globose protoplast 6 to 7.5  $\mu$  in diameter.

Parasitizing *Amoeba verrucosa* it occurs in decaying leaves of *Cucumis sativus* and *Syringa* sp. near Greeley, Colorado.

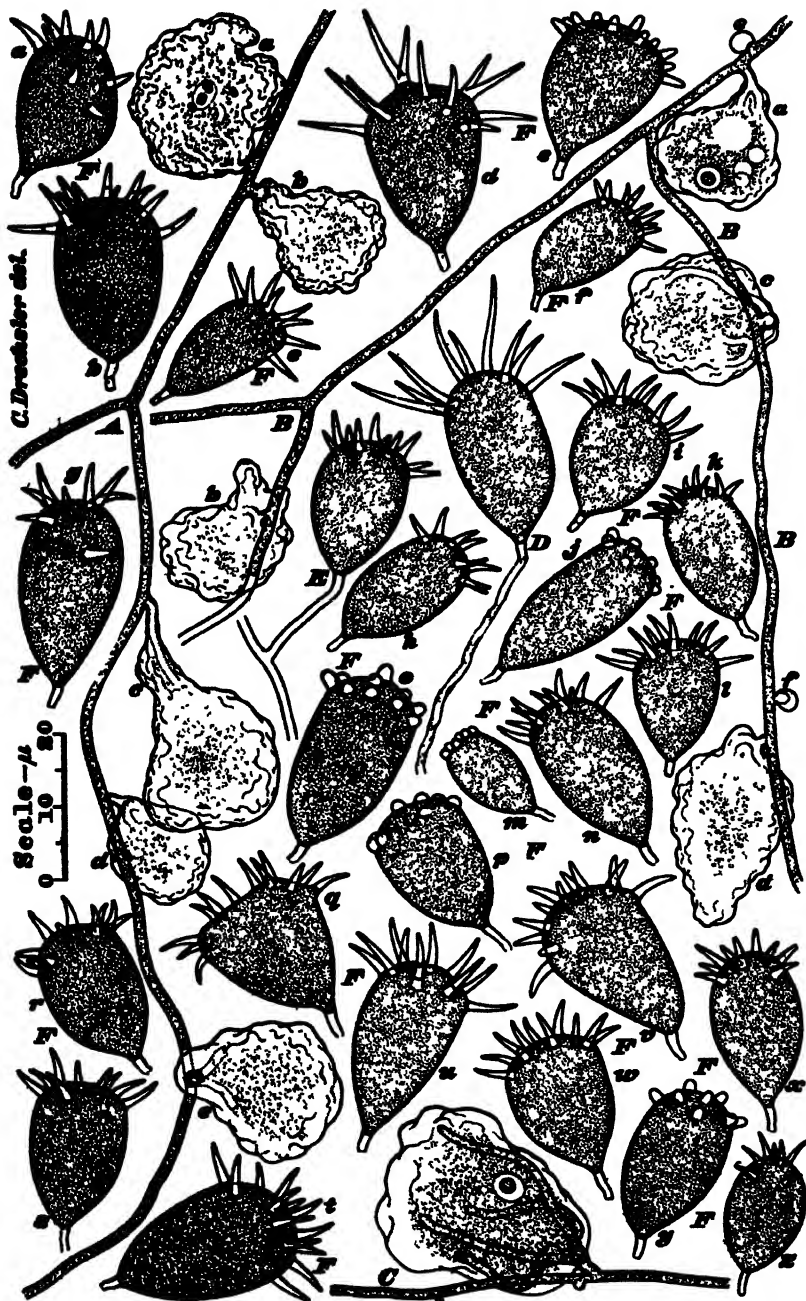
AN AMOEBA-CAPTURING FUNGUS PRODUCING CONIDIA CRESTED  
WITH APPENDAGES

Aside from the decaying material that yielded *Cochlonema aganum*, reference was made in my account of *Nematoctonus haptocladus* to a second lot of vegetable detritus likewise collected near Greeley, Colorado, in October 1944. In this second collection, consisting mainly of partly decomposed remnants of tamarisk leaves, cottonwood leaves, and oleaster leaves, *N. haptocladus* was never found accompanied by the endoparasite just described, but instead occurred a few times in association with an equally new predaceous member of the same family. The new predaceous form came to light in 3 maize-meal-agar plate cultures 14 days after

pinches of the decaying mixture had been superimposed on an established mycelium of *Pythium undulatum* Petersen *sensu* Dissmann; its presence being detected when microscopical explorations carried out with a dry objective revealed a sparse scattering of conidia whose general similarity to the conidia of my *Acaulopage tetraceros* (1: 195-197; 7: 289-291) was relieved by readily noticeable differences pertaining to the number and size of their empty appendages.

On examining under higher magnification several tracts of substratum over which these conidia were distributed only one kind of predaceous mycelium was found present. The hyphae of this mycelium had affixed to them numerous delicately wrinkled empty membranous envelopes measuring 10 to 20  $\mu$  across (FIG. 5, *A*, *a-c*; *B*, *a-d*; *C*), together with some smooth-contoured envelopes usually only about 2.5  $\mu$  in diameter (FIG. 5, *B*, *e*, *f*). It is problematical whether the envelopes of the latter sort came from active individuals of some very minute species of *Amoeba*, or whether they belonged to motile spores of some less familiar type of protozoan; they could, in any case, have held only meager nourishment for the hyphae to which they were fastened. The more capacious wrinkled envelopes unquestionably were pellicles of amoebae referable presumably to a single species. In some instances, where a substantial portion of the protoplasmic contents still remained (FIG. 5, *B*, *a*; *C*), a globose or ellipsoidal structure, measuring 2.5 to 3  $\mu$  in its greatest dimension and containing a slightly darker central body within its hyaline outer layer, appeared to represent a solitary nucleus. Expropriation of the animal's contents was accomplished by a basally branched haustorium consisting, as in *Acaulopage tetraceros*, of assimilative elements approximately equal in width to the mycelial filaments (FIG. 5, *C*).

Connection between the submerged amoeba-capturing mycelium and the appendaged conidia on the surface of the agar substratum was less clearly observable than might have been desired. Development of the conidia evidently entailed here, just as in congeneric forms, evacuation of long stretches of filament; and since the empty membranes soon became indiscernible, the hyphal attachments (FIG. 5, *D*, *E*) of the spores could not often be followed backward as much as 25 or 50  $\mu$ . Nevertheless, it seems fairly certain that two

FIG. 5. *Acaulopage lophosporu*



developmental states must have belonged together, because no other predaceous mycelium, and no other spores at all suggestive of the Zoöpagaceae, were to be found then or later in the same tracts of substratum.

As has been intimated, the conidia (FIG. 5, *F*, *a-x*) in a general way resembled those of *Acaulopage tetraceros* with respect to size and shape; and, moreover, were similarly provided at the base with a short stipe-like empty hyphal part. At the apical end, however, they bore commonly from 8 to 15 empty appendages, while in *A. tetraceros* the number of such parts ranges usually from 3 to 6. Their appendages, though more numerous, were, on the whole, scarcely half as long as those of *A. tetraceros*, sometimes, indeed, being reduced to wart-like protuberances (FIG. 5, *F*, *c, j, m, o, p, y*). In *A. tetraceros* the appendages are regularly borne in a circle around the crown of the spore, whereas in the conidia under consideration they were more often found distributed all over the distal end in a bristling crest. An epithet compounded partly of a word meaning "crest" may therefore perhaps be helpful in distinguishing the fungus producing these conidia from the congeneric form most similar to it.

### ***Acaulopage lophospora* sp. nov.**

Mycelium sparsum; hyphis filiformibus, incoloratis, primum continuis, parce ramosis, plerumque  $1-1.5\ \mu$  crassis, ad animalia minuta inhaerentibus, pelliculam cujusque capti perforantibus, haustorium intus evolventibus quod protoplasma exhaurit; haustorio plerumque ad instar arbusculae ex 3-4 ramulis assumptibus  $5-25\ \mu$  longis et circa  $1.2\ \mu$  crassis constante. Conidia in superficie materiae animalia ambientis singulatim oriunda, hyalina, basi stipitata, apice 8-15 appendicibus praedita: cellula viventi subinde inversum oviformi vel ellipsoidea, sed saepius inversum lageniformi, plerumque  $13-25\ \mu$  longa,  $8-15\ \mu$  crassa; stipite vacuo,  $2-4\ \mu$  longo,  $.9-1.4\ \mu$  crasso; appendicibus vacuis, vulgo acute subulatis,  $3-13\ \mu$  longis, basi  $.8-1.5\ \mu$  crassis, subinde obtuse conicis vel verruciformibus,  $1.5-3\ \mu$  longis,  $.8-1.5\ \mu$  crassis.

Amoebas plerumque  $10-20\ \mu$  latas capiens consumensque habitat in foliis plantarum (specierum *Syringae*, *Populi*, *Tamaricis*) putrescentibus prope Greeley, Colorado.

Mycelium sparse; vegetative hyphae filiform, colorless, sparingly branched, originally continuous, mostly  $1$  to  $1.5\ \mu$  wide, adhering to minute animals, perforating the pellicle of each captive and intruding a haustorium to appropriate the protoplasmic contents: haustorium bushlike, often consisting of 3 or 4 assimilative branches

## DECHLER: THREE NEW ZOOPHAGACEAE.

5 to 25  $\mu$  long and about 1.2  $\mu$  wide. Conidia formed singly on the surface of the material surrounding the animals, colorless, stipitate at the base and provided at the apex with 8 to 15 appendages: the living cell sometimes obovoid or ellipsoid but more often inversely flask-shaped, usually 13 to 25  $\mu$  long and 8 to 15  $\mu$  wide; the stipe empty, mostly 2 to 4  $\mu$  long and .9 to 1.4  $\mu$  wide; the appendages empty at maturity, usually acutely awl-shaped, 3 to 13  $\mu$  long and .8 to 1.5  $\mu$  wide at the base, but sometimes bluntly conical or wart-like, then mostly 1.5 to 3  $\mu$  long and .8 to 1.5  $\mu$  wide.

Capturing and consuming amoebae, mostly 10 to 20  $\mu$  wide, it occurs in decaying leaves of *Syringa* sp., *Populus* sp., and *Tamarix* sp., near Greeley, Colorado.

### AN AMOEBA-CAPTURING FUNGUS PRODUCING CONIDIA BESSET WITH LONGISH FINGER-LIKE APPENDAGES

A maize-meal-agar plate culture that on May 5, 1945, was planted with softened discolored roots from a wilting pansy (*Viola tricolor* L.) plant newly dug up in Mt. Rainier, Md., showed, when explored microscopically 21 days later, sparsely scattered conidia beset with bristling appendages in a manner reminiscent of the amoeba-capturing fungus I described earlier (7: 274-278) as *Acaulopage lasiospora*. On closer examination it was found that the conidia in question were, on the whole, appreciably smaller than those of *A. lasiospora*, and that they more frequently tapered noticeably toward the proximal end (FIG. 6, *A*, *a-x*), thereby acquiring more often a somewhat turbinate shape. Their appendages showed marked distinctiveness in that they were longer than the appendages of *A. lasiospora*, and only about half as numerous.

At the time the conidia first came under observation the mycelium from which they originated was for the most part already empty of contents, making it very difficult to trace the slender hyphae for any distance. Unfortunately, besides, *Acaulopage tetraceros* was present in considerable abundance throughout the culture, so that when membranous remains of amoebae were found affixed to mycelial elements it was usually not possible to ascertain which fungus had been concerned in particular instances of capture. Details relating to haustorial development must consequently await an accession of less ambiguous material. In the meantime the

curious conidial ornamentation would seem to justify amply the recognition in the Zoöpagaceae of an additional member to be known by a specific epithet compounded of two words meaning "porcupine" and "seed," respectively.

**Acaulopage hystricospora** sp. nov.

Mycelium sparsum, parce ramosum; hyphis incoloratis, primo continuis, circa  $1\ \mu$  crassis, ad animalia minuta inhaerentibus, pelliculam cujusque capti perforantibus, haustorium intrudentibus quod protoplasma exhaurit. Conidia in superficie materiae animalia ambientis singulatim oriunda, incolorata vel subinde languide flavida, globosa vel elongato-ellipsoidea vel applanato-ellipsoidea vel turbinata, plerumque  $7.5\text{--}12.5\ \mu$  longa,  $7\text{--}14\ \mu$  crassa, basi interdum minute stipitata, prope basin semper glabra, medio interdum glabra interdum appendicibus vestita, apice semper appendicibus vestita; appendicibus in summa 10–50, in maturitate vacuis, digitiformibus, plerumque  $2\text{--}6.5\ \mu$  longis,  $.7\text{--}.9\ \mu$  crassis.

Amoebas capiens consumensque habitat in radicibus *Viola tricoloris* putrescentibus in Mt. Rainier, Maryland.

Mycelium sparse, sparingly branched; vegetative hyphae colorless, originally continuous, about  $1\ \mu$  wide, capturing minute animals through adhesion, perforating the pellicle of each captive, and extending into it a haustorium to appropriate the protoplasmic contents. Conidia produced singly on the surface of the material underlying or surrounding the animals, colorless or sometimes faintly yellowish, globose or prolate ellipsoidal or oblate ellipsoidal or turbinate, mostly  $7.5$  to  $12.5\ \mu$  long and  $7$  to  $14\ \mu$  wide, sometimes minutely stipitate, always glabrous in the region surrounding the hilum, glabrous or beset with appendages in the equatorial zone, regularly beset with appendages at the distal end; the appendages commonly numbering 10 to 50 in all, empty at maturity, finger-shaped, mostly  $2$  to  $6.5\ \mu$  long and  $.7$  to  $.9\ \mu$  wide.

Capturing and consuming amoebae, if occurs in decaying roots of *Viola tricolor* in Mt. Rainier, Maryland.

A STRAIN OF STYLOPAGE RHABDOSPORA PRODUCING LARGISH  
CONIDIA

Many of the cultures that, after being planted with the cucumber-lilac detritus from Colorado, yielded *Cochlonema agamum*, often in association with *Nematoctonus haptocladus*, permitted abundant development also of *Stylopaga rhabdospora*. On the whole the Colorado strain showed satisfactory agreement with the original description of the species, but its conidia, ranging in length from

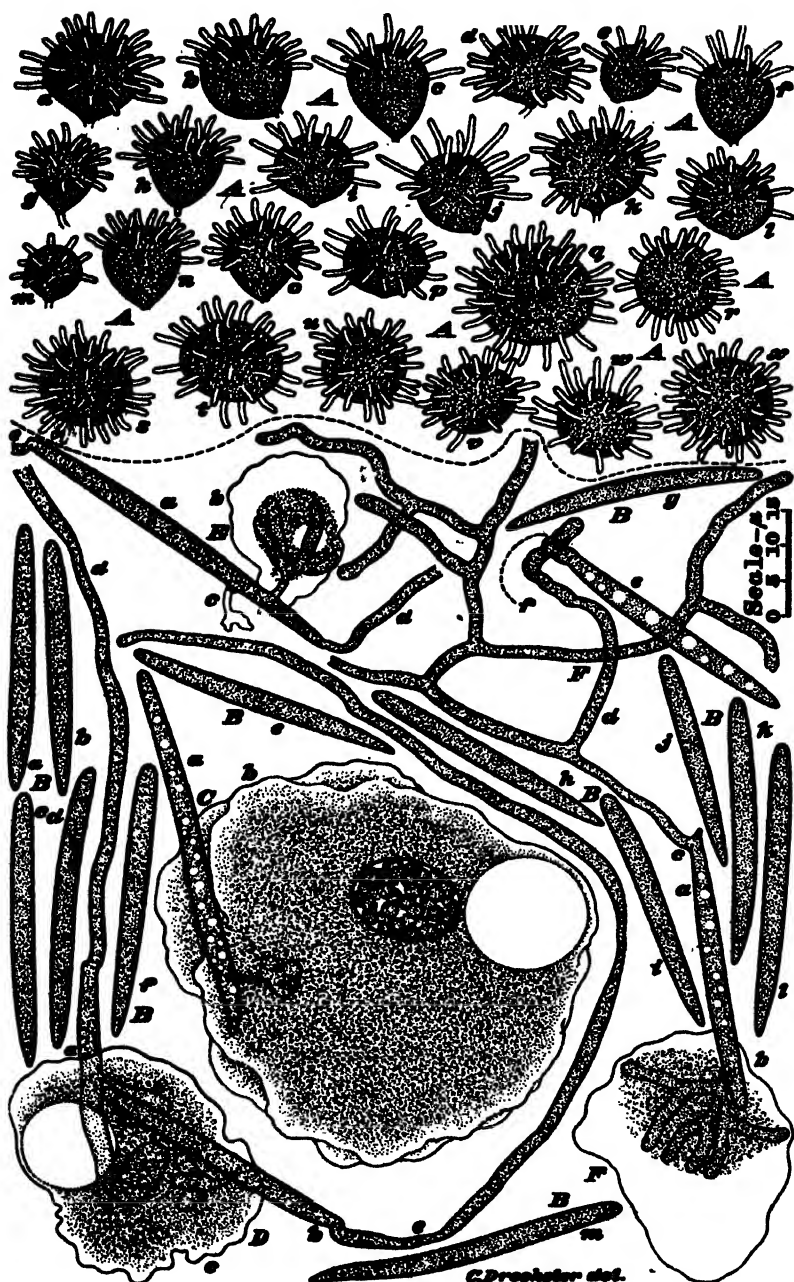


FIG. 6. A. *Acaulopage hystricospora*  
B-F. *Stylopape rhabdospora*

30 to 52  $\mu$ , and in width from 2.7 to 3.2  $\mu$  (FIG. 6, *B*, *a-m*; *C*, *a*; *D*, *a*, *b*; *E*, *a*; *F*, *a*, *c*), exceeded the dimensions previously given. The *Amoeba* attacked by it was manifestly of the same species as the one earlier found serving as prey, though some individuals measured no less than 50  $\mu$  when drawn into a rounded shape (FIG. 6, *C*, *b*). While the single prolate-ellipsoidal nucleus present in these larger animals measured as much as 14  $\mu$  in length and 11  $\mu$  in width (FIG. 6, *C*, *b*) it revealed, like the smaller nuclei figured earlier (3: p. 375, FIG. 4, *A*, *C*), about 30 to 35 oblate ellipsoidal bodies distributed peripherally; about 10 to 12 of the bodies being usually visible in profile view. The larger animals as well as the smaller ones (FIG. 6, *D*, *c*; *E*, *b*; *F*, *b*) were often attacked directly by adhering conidia, which in such instances would intrude a haustorium while at the same time putting forth one (FIG. 6, *D*, *d*, *e*; *F*, *c*) or two (FIG. 6, *E*, *d*, *e*) germ hyphae. Again, much as in the earlier material, a hyphal branch (FIG. 6, *F*, *d*) on encountering a germ hypha from a conidium nearby (FIG. 6, *F*, *c*) would often conjugate with it (FIG. 6, *F*, *f*) to initiate development of a zygospore.

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## EXPLANATION OF FIGURES

FIG. 1. *Cochlonema agamum*; drawn to a uniform magnification with the aid of a camera lucida;  $\times 1000$  throughout. *A*, Specimen of *Amoeba verrucosa* still active though infected with 3 thalli, *a-c*; *d*, *c*, same thallus as *c*, but drawn 30 minutes later and 4 hours later, respectively; *n*, host nucleus in virtually healthy condition; *o*, same host nucleus 6 hours later, showing abnormal mottling in outer layer; *p*, same host nucleus, restored to virtually normal condition through incubation for 16 hours at  $15^{\circ}$  C.; *v*, contractile vacuole of host; *w*, digestive vacuoles crowded with ingested bacteria; 20 ingested spores of a mucoraceous fungus are shown scattered through the protoplasm. *B*, Specimen of *Amoeba verrucosa* still actively motile though infected with seven thalli, *a-g*, of various sizes; *n*, host nucleus; *v*, contractile vacuole containing a group of spores from a mucoraceous fungus; 14 other similar spores are shown distributed through the host cytoplasm. *C*, Small specimen of *Amoeba verrucosa* still motile though infected with three thalli, *a-c*; *n*, host nucleus; *v*, contractile vacuole, *w*, digestive vacuole containing ingested bacteria; 14 ingested spores of a mucoraceous fungus are shown scattered through the cytoplasm. *D*, Small disabled specimen of *Amoeba verrucosa* infected with a large thallus, *a*, that is putting forth two reproductive filaments; *n*, host nucleus; *v*, contractile vacuole; *w*, digestive vacuole crowded with bacteria; six ingested spores of a mucoraceous fungus are shown imbedded in the host cytoplasm.

FIG. 2. *Cochlonema agamum*; drawn to a uniform magnification with the aid of a camera lucida;  $\times 1000$  throughout. *A*, Specimen of *Amoeba verrucosa* still capable of slight movement though infected with 15 thalli, *a-m*, *o*, *p*, mostly rather small; *n*, host nucleus abnormal in the organization of its darker material; *v*, contractile vacuole. *B*, Large specimen of *Amoeba verrucosa* still capable of slight movement though infected with 15 thalli of moderate size, *a-m*, *o*, *p*; *n*, host nucleus of virtually normal appearance; *v*, contractile vacuole. *C*, Portion of a thallus showing a reproductive filament and its connection with a young growing conidiiferous hypha; the latter from lack of space being shown in parts connected in proper sequence by broken lines. *D*, Catenated conidia as found in the proximal portion, *a*, and in a more distal portion, *b*, of a chain. *E*, Random assortment of disarticulated conidia, showing ordinary variations in size and shape. *F*, Small thallus that has yielded most of its contents in prolonging its single reproductive filament into a zygothoric hypha from whose distal cell a young azygospore has burgeoned forth laterally. *G-L*, Mature azygospores to each of which is attached the empty membrane of the distal cell.

FIG. 3. *Cochlonema agamum*; drawn to a uniform magnification with the aid of a camera lucida;  $\times 500$  throughout. *A*, Specimen of *Amoeba verrucosa* still capable of some movement though infected with a large thallus, *a*; *n*, host nucleus of nearly normal appearance; *v*, contractile vacuole; *w-s*, digestive vacuoles to a large extent crowded with ingested bacteria. *B*, Disabled specimen of *Amoeba verrucosa* whose contents have been almost completely assimilated by the large thallus, which in turn has lost most of its protoplasm in putting forth conidial apparatus from three reproductive filaments, *a-c*; a short diverticulum, *d*, evidently representing a fourth repro-

ductive filament that aborted at an early stage. *C*, Specimen of *Amoeba verrucosa* whose contents have been almost completely assimilated by seven thalli, *a-g*, which collectively have given rise to the 19 conidiiferous hyphae and conidial chains *h-s*: *a* having given rise to *h*; *b* to *i*, *j*; *c* to *k*, *l*; *d* to *m*, *n*, *o*, and to *p*, *q*; *e* to *r*, *s*; *f* to *t*; *g* to *u*, *v*, and to *w*, *x*, *y*, *z*. *D*, Specimen of *Amoeba verrucosa* killed by 2 large thalli, *a* and *b*, each of which has given rise to two reproductive filaments; the more proximal filament from thallus *a* having then produced the zygomorphic branches *c* and *d*; the more distal filament from thallus *a* in like manner having produced the zygomorphic branches *e*, *f*, *g*; the proximal filament from thallus *b* having produced the zygomorphic branches *h*, *i*, *j*, *k*; the more distal filament from thallus *b* having produced the zygomorphic branches *l* and *m*.

FIG. 4. *Cochlonema agamum*; drawn to a uniform magnification with the aid of a camera lucida;  $\times 1000$  throughout. *A*, Specimen of *Amoeba verrucosa* disabled from infection by six thalli, *a-f*, five of which, *a-e*, have each put forth a reproductive filament that in every instance is extending zygomorphic branches into the surrounding material—thallus *a* in this manner giving rise to branches *k*, *l*, *m*; thallus *b* to branches *q*, *r*; thallus *c* to branches *s*, *t*, *u*, *v*; thallus *d* to branches *w*, *x*; and thallus *e* to branches *y*, *z*; *n*, host nucleus. *B-L*, Distal portions of zygomorphic branches, showing development of azygospore in various positional relationships to the terminal cell, and in two instances (*K*, *L*) showing ramification of the terminal cell. *M-T*, Detached mature azygospores, showing variations in size and sculpturing. *U-W*, Empty thalli of moderate size, with three (*U*) or four (*I'*, *W*) transverse partitions, and with one (*U*, *I'*) or two (*W'*) reproductive hyphae; the distal portion of each thallus collapsing and evanescing.

FIG. 5. *Acaulopage lophospora*; drawn to a uniform magnification with the aid of a camera lucida;  $\times 1000$  throughout. *A*, Portion of mycelium to which are affixed the virtually empty pellicles of five amoebae, *a-e*. *B*, Portion of mycelium to which are affixed: *a*, one moribund amoeba that still reveals a nucleus, a contractile vacuole, and a remnant of cytoplasm; *b-d*, three virtually empty pellicles of conspecific amoebae; *e*, *f*, two empty envelopes of very minute microorganisms. *C*, Portion of hypha to which is attached a moribund amoeba largely expropriated of its cytoplasm. *D*, Conidium shown attached to an empty collapsing, evanescent hypha. *E*, Conidium shown attached to a short branch arising from a mycelial filament. *F*, *a-s*, Detached conidia showing variations in size and shape of the living cell, as well as in size, shape, number and arrangement of the appendages.

FIG. 6. Drawn to a uniform magnification with the aid of a camera lucida;  $\times 1000$  throughout. *A*, *Acaulopage hystricospora*: Detached conidia, *a-r*, illustrating usual variations in size and shape of the living cell, as well as in number, size, and arrangement of the appendages; 16 of them (*a-p*) being shown as viewed at a right angle to the longitudinal axis; two (*q*, *r*) as viewed from below, with the hilum surrounded by a glabrous area; six (*s-x*) as viewed from above, with appendages arising everywhere from the apical surface. *B-F*, *Stylopage rhabdospora* (strain from Greeley, Colorado): *B*, Detached conidia, *a-m*, showing variations in size and shape. *C*, Conidium, *a*, infecting a large individual amoeba, *b*; nucleus of animal being drawn to show all the oblate ellipsoidal bodies distributed throughout its periphery.

*D*, Two conidia, *a* and *b*, infecting a small amoeba, *c*, while putting forth the germ tubes *d* and *e*, respectively. *E*, Conidium, *a*, that has intruded one haustorium into a small captured amoeba, *b*, besides producing and later evacuating another haustorium, *c*, while at the same putting forth two germ hyphae, *d* and *e*. *F*, Conidium, *a*, which has largely depleted a captured amoeba, *b*, by means of a haustorium, besides putting forth a germ hypha, *c*, one of whose branches, *d*, has encountered the germ tube from a neighboring conidium, *e*, and is uniting apically (*f*) with it.



# STUDIES ON SOME FUNGI FROM NORTH-WESTERN WYOMING. I. PYRENO-MYCETES

LEWIS E. WEHMEYER \*

(WITH 20 FIGURES)

During the summer of 1940, the writer spent several months at the Rocky Mountain Field Station of the University of Michigan (Camp Davis), at the mouth of Hoback Canyon, some seventeen miles south of Jackson, Wyoming. During this period, collections and observations of the fungi of this region were made within a radius of some forty or fifty miles. This area is very interesting from a mycological viewpoint. It includes the Jackson Hole area about the Snake River, the Teton National Park, with its rugged peaks, a number of other mountain ranges and a large area of high, dry, hilly sagebrush country.

At first inspection this does not appear to be a region favorable for fungus growth. However, it is of special interest in several respects. The fleshy fungi, it is true, appear to be absent over a large part of the area and during most of the year, but even these do occur, and in abundance, after the very local, but often heavy showers of late summer. To collect these one must be on the right spot at the right time—a few days after such periodic showers. Only a few such opportunities were encountered, and no great attention was paid to fleshy forms.

Parasitic fungi, such as leaf spots, rusts, etc., also abound. The region has a large and varied host flora which will yield an abundance of such parasites. Dr. Solheim's accounts and collections (11: pt. 1-4) have recorded many of these. A third flourishing fungous flora, and the one in which the writer was most interested, is that found on the stems of herbaceous and woody plants. The Pyrenomycetes and Fungi Imperfecti on dead stems grow luxuriantly, particularly at the higher elevations and in the mountain meadows. In these situations there is a heavy winter snow-

\* Papers from the Department of Botany of the University of Michigan no. 764.

fall which remains late in the spring, often into the early part of July. There is also a luxuriant growth of herbaceous plants in these mountain areas and a great variety of host species are represented. The dead herbaceous stems are covered and protected by heavy snow all winter and are thoroughly saturated with moisture for a long period during the spring. These conditions are ideal for the growth and maturation of stem fungi. An excellent opportunity was thus presented to make extensive collections on a wide variety of hosts and to make a comparative study of them, which it was hoped might throw light on several vexatious questions.

Some 115 collections were made on the stems of some seventy different host genera. Certain generalities stand out from the study of these collections. A number of species are usually found associated upon the same stems. Frequently as many as eight fungi (No. 1114 on *Aquilegia*, 1121 on *Agastache*, 1134 on *Linum* etc.), including pycnidial stages, were found on the same collection of stems. On the *Agastache* stems cited, five species of *Plecospora* were found. In all, 298 such "occurrences" were recorded from these 115 collections. The fruit bodies of the various species are often intricately intermingled but sometimes widely scattered. They are, in many cases, difficult to distinguish even under a binocular dissecting microscope, and the presence of a species is often discovered only after a microscopic mount has been made. This difficulty of separation no doubt explains much of the confusion in the literature concerning the interpretation of various exsiccata and type material, and makes the inclusion of careful drawings of spores and other diagnostic characters all the more important in the description of these fungi.

Likewise, such multiple occurrences indicate the dangers of interpreting genetic connections by mere association alone. Any widely distributed conidial stage, such as *Heteropatella umbilicata*, can be found associated with a wide variety of ascus stages of different species, and the reverse is likewise true of most of the ascus stages. Occasionally, a repeated association of two such stages, as the occurrence of *Scolecotrichum*-like conidial forms with *Mycosphaerella Tassiana*, may indicate a greater probability of their genetic relation, but does not constitute proof.

Most of the species on dead stems are common and ubiquitous

on many host genera (*Pleospora permunda*, *Mycosphaerella Tassiana*, *Heteropatella umbilicata* etc.), whereas others seem to be limited to one host genus (*Sphaerulina Gentianae*, *Apiocarpella* (sp.), *Pleospora* (sp.) or seem to favor certain families of hosts or certain groups of host genera (*Leptosphaeria Erigerontis*, *Mycosphaerella dolichospora* etc.). The most frequent genera in this region are *Pleospora*, *Mycosphaerella* and *Leptosphaeria* in the order named. Many species of these stem fungi are supposed to start their cycle as parasites on the living plant parts and form the ascus stage saprophytically over winter on the dead parts. Those species mentioned above as being limited as to host, may represent such restricted parasites but more extensive collections are needed, which when made often reveal a range that is much wider than might be suspected. It seems quite obvious that most of these stem fungi are not limited in their host range, and seem to develop saprophytically. Some species, as *Mycosphaerella Tassiana* and *Pleospora permunda*, can be found on almost every collection that is made. An interesting side-light on this distribution is that a species often appears in a few localities but on a number of different hosts. This was quite apparent in the study of *Pleospora*, where collections segregated on a morphological basis alone often turned out to have come from one or a few limited localities but on different hosts. It appears that a fungous species becomes established at a station and spreads readily in that area to the stems of many different higher plants.

Lying at an altitude of from 6000 to 11,000 feet, this region shows a definite arctic-alpine component in its fungous flora. Such species as *Heteropatella umbilicata*, *Mycosphaerella Tassiana*, many of the clathrate species of *Pleospora*, etc., are reported in almost all of the lists from localities of high altitude or latitude. There also seems to be a rather distinct component of the fungous flora of herbaceous stems which is found chiefly above 8000 to 8500 feet elevation. Too few collections have been made to be greatly significant, but all collections, for instance, of *Nectriella Pedicularis*, *Apiosporella alpina*, *A. Mimuli*, *Mycosphaerella dolichospora*, *Sphaerulina Gentianae*, *Heteropatella umbilicata*, *Sirexipula* (sp.) and many other species, were taken from elevations of 8500 feet or above. Again, very few species were found to occur both at

the lower elevations of 6000 to 8000 feet and at the higher levels above 8000 feet. Additional collections may show other interesting relationships.

The present paper is concerned with the Pyrenomycetes (exclusive of *Pleospora* and *Leptosphaeria*) found on stems. In the course of this discussion, it will be necessary to refer to certain new species of the Fungi Imperfecti which are to be described in a following paper. Such species are referred to in parentheses, *i.e.* *Phoma* (sp.). The taxonomic situation in the genera *Pleospora* and *Leptosphaeria* is in such a confused condition that a special study has been made of the fairly large series of collections of these genera, and will be presented in a separate paper. Similar difficulties are found in other large genera, as *Phoma*, *Mycosphaerella*, *Septoria*, etc., where many described species are based upon their occurrence upon some host species or genus, rather than upon any morphologic distinction.

The chief localities at which collections were made are briefly described below, and are later referred to merely by these names. Inasmuch as all collections were made during the summer of 1940 and within fifty miles of Jackson, Wyoming, the year and town are omitted from collection citations. Small letters after collection numbers indicate series of species occurring on the same collection of stems.

**CAMP DAVIS:** Situated on flat land at about 6000 feet elevation, at the mouth of Hoback Canyon, on the Hoback River, some seventeen miles south of Jackson, Wyo. Surrounded by dry gravelly flats and foothills, covered largely with a sagebrush vegetation with abundant herbaceous growth in the richer and moister areas. Some poplar and forest growth on low hills behind the camp, elevation up to 6500 ft.

**CREAM PUFF MT.:** A local name for a mountain north of Camp Davis, across the Hoback River, with an elevation of 9665 ft. Most collections were taken from the upper slopes and crest, which are covered with an herbaceous flora of the alpine meadow type.

**HOBACK CANYON:** River flats and steep slopes along the Hoback River and ravines of tributary streams. Mostly rocky slopes with a brushy or coniferous cover and scattered small meadows. Elevation 6000-7000 feet.

GLORY MT.: Peak directly north of the Teton Pass road at its summit, consisting of steep rocky slopes, sparsely wooded. Elevation 8500 feet at the pass, 10,000 feet at the top. This slope, although exposed, is thoroughly watered by melting snow and supports a great variety of herbaceous alpine plants. Summit covered with a stunted alpine growth, with a few small meadows just below. Most collections made between 9000 and 10,000 feet.

SOUTH OF TETON PASS: This refers to a region south of Teton Pass road, which is a high ridge running southward. It consists of steep slopes and high meadows, mostly open, but in part forested with conifers, at an elevation of 8500-9500 feet. This area includes large areas of lush meadows mostly above 9000 feet which yielded many collections.

TOGWOTEE PASS: Twenty-five to thirty miles east of Moran, Wyoming. Collections were made on the slopes and summit of Breccia Peak, at an altitude of 9500 to 10,500 feet. The lower slopes are wooded or park-like, the upper slopes covered with a continuous alpine meadow with many herbaceous species.

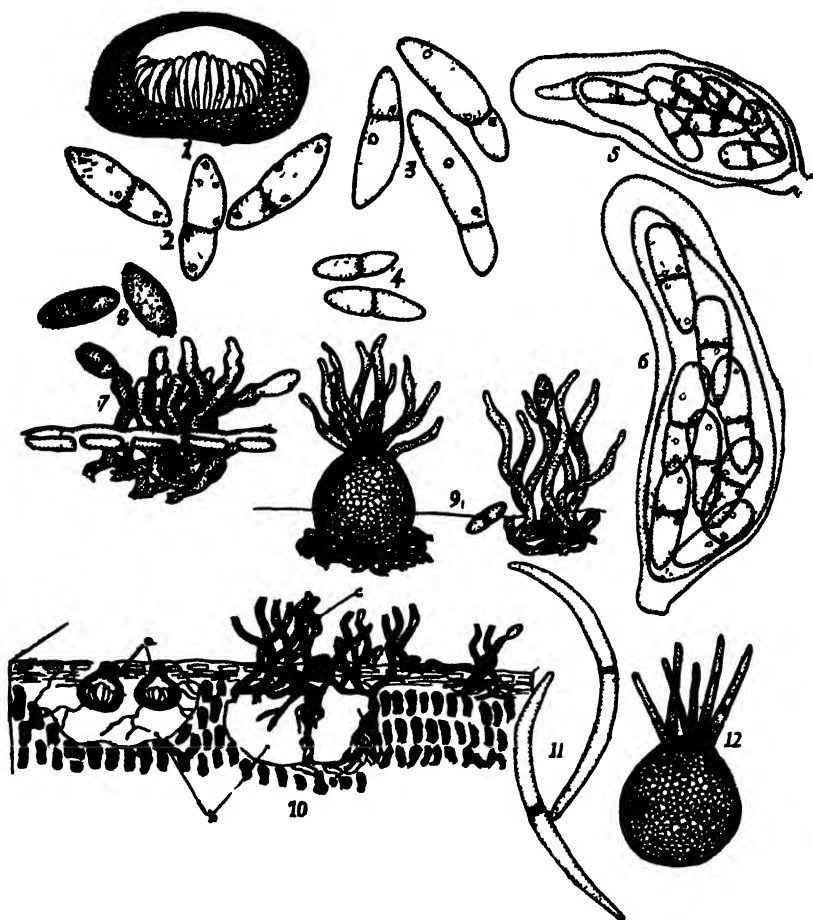
SKYLINE TRAIL: A trail leading over the high plateau behind (to the west of) the main Teton Range. Collections were made on two separate trips. The first on July 24, was on the north portion of the trail, up the south fork of Cascade Canyon. Collections were made in two high alpine meadows above timber line, at elevations of 10,500 to 11,000 feet. On August 4, a few collections were made along the southern portion of the trail on the lower wooded slopes of a branch of Death Canyon and at "Overlook," at elevations of 9000-9500 feet.

### *Apiosporella alpina* sp. nov. (FIG. 2)

Perithecia dense dispersa, deinde erumpentia, superficialia (ab exfoliatione epidermatis), atra, nitida, depresso globosa, 250-350  $\mu$  diametro, 200-250  $\mu$  alta; pariete 30-50  $\mu$  crasso, ex parenchymate crasso, atro constituto. Asci cylindrici-clavati, 85-100  $\mu$  longi, 10-13  $\mu$  crassi, apicali membrana incrassata. Sporae biseriatae ellipsoideales vel inaequilaterales, 16-21.5  $\mu$  longae, 4.5-6  $\mu$  crassae, ad apicem attenuatae, inaequaliter bicellulae, cellula apicali brevior quam altera, 8-9  $\mu$  longae.

Specimen typicum in caulibus vetustis *Pedicularis bracteosa* Benth., prope Togwotee Pass, Teton Co., Wyoming, 8 Julii, 1940, legit L. E. Wehmeyer, sub numero 1095.

Perithecia thickly scattered, formed beneath the epidermis but soon erumpent-superficial by exfoliation of that tissue, shiny black, flattened-spheric,  $250-350 \times 200-250 \mu$ , walls thick ( $30-50 \mu$ ), sclerotial, of dark, coarse parenchyma, sharply delimited next the



FIGS 1-12 Wyoming Pyrenomycetes

hymenium. Asci cylindric-clavate, wall somewhat thickened at the apex,  $85-100 \times 10-13 \mu$ . No paraphyses nor paraphysis-like structures were seen. Spores biseriate, ellipsoid to inequilateral, usually narrowed toward one end and with a septum excentrically placed near this end, hyaline, variable in size with maturity,  $16-21.5 \times 4.5-6 \mu$ , shorter cell  $8-9 \mu$  long.

Togwotee Pass: July 8, on *Pedicularis bracteosa* Benth., leg. L. E. Wehmeyer (1095) (Type), and *P. racemosa* Dougl. (1097a). Skyline Trail: July 24, on *Hedysarum* sp. (1173b).

Although there are no paraphyses in these perithecia, their large size suggests *Didymella* rather than *Mycosphaerella*. Saccardo erected the genus *Apiospora* for unequally two-celled forms of simple Pyrenomycetes of this type. Höhnelt (4: 1215) claimed that the type of this genus, *A. Montagnei* Sacc., was a stromatic dothideaceous type on grasses and erected a new genus *Apiospor-ella* for the simple, so-called sphaeriaceous, *Didymella*-like species, but gave no description nor designated any type. Theissen (13: 275) later discussed this genus, gave a diagnosis, and chose *Apiospor-ella sepincolaeformis* (Sacc.) Theiss. as the type. Several species, including *Apiospor-ella sepincolaeformis* (*A. rhodophila* (Sacc.) Höhn.), *Didymella eupyrena* Sacc., *D. nivalis* (Fck.) B. & V., and *D. Delphinii* Earle, have spores from  $15-25 \times 7-9 \mu$  which cover the range of spore size of this and the following species. These four collections of *Apiospor-ella* present a more or less overlapping series of spore sizes varying with degree of maturity, but seem to fall into the two species here described, which is supported by the association of a *Phoma* (sp.) with the two collections of this species on *Pedicularis* and of a *Macrophoma* (sp.) with that on *Mimulus*, if these represent conidial connection. Using this same line of reasoning, the collection on *Hedysarum* (1173b) might be considered distinct, because it is associated with an *Apiocarp-ella* (sp.). This *Apiocarp-ella*, on the other hand, is associated on another collection of *Hedysarum* (1126) with *Sphaeru-lina inaequalis*. All of which reveals the dangers of using such circumstantial evidence in the erection of species. Only comparison with type material can determine whether any or all of these collections are identical with the species mentioned.

### ***Apiospor-ella Mimuli* sp. nov. (FIGS. 1 & 3)**

Perithecia dense dispersa in areis interruptis, depresso globosa, 400-500  $\mu$  diametro, atra, erumpentia, superficialia; pariete 30-50  $\mu$  crasso, crasse parenchymatoso, atro; ostiolis papilliformibus. Asci clavati, basi angustati, 90-100  $\mu$  longi, 16-18  $\mu$  crassi, pariete apicali incrassato. Sporae biseriatae, fusiformi-ellipsoideae vel asymmetricae vel paululo curvatae, inaequaliter bi-cellulae, hyalinae, 23-32  $\mu$  longae, 5.3-8.5  $\mu$  latae, cellula inferiore circa 10  $\mu$  longa.

Specimen typicum in caulibus vetustis *Mimuli Lewisii* Pursh, secus viam "Skyline Trail," Teton National Park, Wyoming, 24 Julii, 1940, legit L. E. Wehmeyer, sub numero 1171.

Perithecia thickly scattered locally, 400–500  $\mu$  in diameter, flattened-spheric, black, formed beneath the epidermis but soon erumpent-superficial, ostiole papillate, walls 30–50  $\mu$  thick, consisting of coarse black parenchyma. Asci clavate with a tapered base and a thickened apical wall, 90–100  $\times$  16–18  $\mu$ . Spores biserial, fusoid-ellipsoid to inequilateral or slightly curved, unequally two-celled, hyaline, 23–32  $\times$  5.3–8.5  $\mu$ , lower cell about 10  $\mu$  long.

On *Mimulus Lewisii* Pursh, Skyline Trail, July 24, leg. L. E. Wehmeyer (1171) (Type).

This species differs from the preceding in the definitely larger spores. It is associated with a *Macrophoma* (sp.).

#### DIATRYPELLA DISCOIDEA Cke. & Pk.

On *Betula glandulosa* Michx., Camp Davis, July 4 (1080).

This collection shows the typical circular discs, long stalked asci, spore bearing portion 35–55  $\times$  7–8  $\mu$  and allantoid spores, yellowish in mass, 3.5–5.5  $\times$  0.8–1  $\mu$ .

#### *Didymella Castillejae* sp. nov. (FIG. 4)

Perithecia dense dispersa, superficialiter erumpentia, globosa vel paulum depressa, 200–300  $\mu$  diametro, 150–200  $\mu$  alta; ostiolo centrali, papilliformi; pariete 50–80  $\mu$  crasso, bistrato, exteriore crasso, atro, interiore tenuiore, hyalino. Asci longe cylindrici, 55–70  $\mu$  longi, 7–9  $\mu$  crassi, membrana ad apicem incrassata; paraphysibus nullis, sed pseudoparaphyses adsunt. Sporae biserialae fusoido-ellipsoideae, bicellulae, hyalinae, ad septum paulo constrictae, 12.5–14  $\mu$  longae, 3.5–4.5  $\mu$  crassae.

Specimen typicum in caulibus vetustis *Castillejae miniatae* Dougl., prope Camp Davis, Jackson, Wyoming, 24 Junii, 1940, legit L. E. Wehmeyer, sub numero 1043.

Perithecia rather thickly scattered beneath the epidermis, soon erumpent, globose or somewhat flattened, 200–300  $\times$  150–200  $\mu$ , with a central papillate ostiole and thick (50–80  $\mu$ ) stromatic walls consisting of an outer layer of coarse black parenchyma and an inner thin hyaline layer. Asci long cylindric, with a thickened apical wall, 55–70  $\times$  7–9  $\mu$ . No true paraphyses, but some interthecial tissue present. Spores biserial, fusoid-ellipsoid, two-celled, hyaline, slightly constricted at the septum, 12.5–14  $\times$  3.5–4.5  $\mu$ .

On *Castilleja miniata* Dougl., Camp Davis, June 24, leg. L. E. Wehmeyer (1043) (Type).



**DIDYMELLA EXIGUA** (Niessl) Sacc.

Perithecia scattered, formed beneath the epidermis, soon erumpent, globose to strongly flattened,  $250-400 \times 200-300 \mu$ , with a central conic to strongly flattened ostiole, walls  $20-40 \mu$  thick, composed of coarse black parenchyma, asci clavate, apical wall somewhat thickened, not fasciculate, with a slight amount of interthecial tissue, but no true paraphyses,  $55-70 \times 9-12 \mu$ . Spores biseriate, fusoid-ellipsoid, often inequilateral or slightly curved, two-celled, hyaline, slightly constricted at the septum,  $16-19.5 \times 4.3-5.5 \mu$ .

South of Teton Pass: on *Pedicularis contorta* Benth., July 11, (1135).

Holback Canyon: Red Creek, on *Senecio scrra* Hook., July 25, (1184).

No species are described on these hosts that fit these collections, but they are nearest to *D. exigua*, described from various herbaceous hosts.

**Guignardia Epilobii** (Wallr.) comb. nov. (FIGS. 13 & 14)

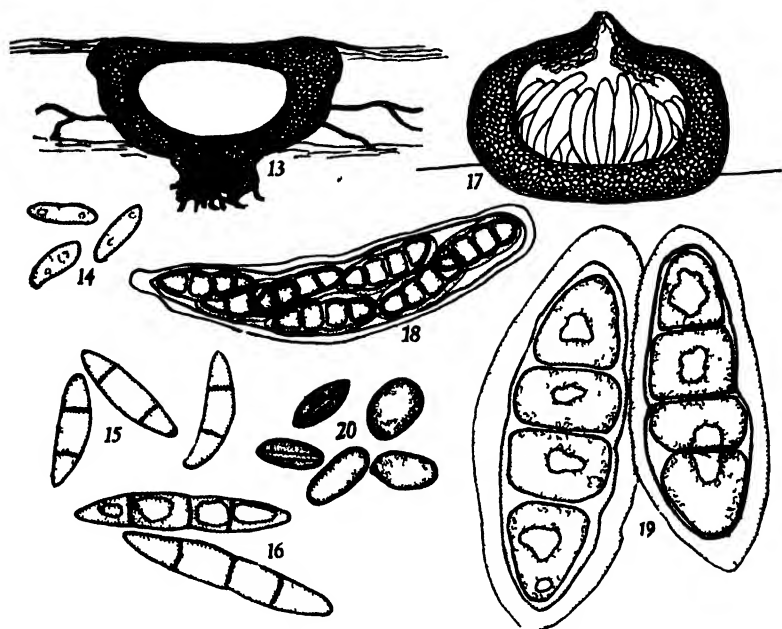
*Sphaeria Epilobii* Wallroth, Flora Cryptogamica Germ. 2: 771. 1833.

Perithecia thickly scattered, on the surface as minute, black, circular, sunken, saucer-shaped spots, formed beneath the epidermis, globose, or usually with a flattened upper surface, becoming collapsed,  $150-300 \times 100-150 \mu$ , with a central pore-like ostiolar rupture of the thick dothideaceous wall of dark colored pseudoparenchyma. The perithecia are often anchored in the substrate by a stromatic foot of this same tissue,  $100 \times 70-100 \mu$ . Asci clavate, with a tapering base,  $40-75 \times 7-10 \mu$ , wall thin, collapsing, but persistent when empty, emitted in a fasciculate group, without any paraphyses. Spores biseriate, broad fusoid-ellipsoid, one-celled, hyaline,  $10-14 \times 3-5.3 \mu$ .

South of Teton Pass: on *Epilobium angustifolium* L., July 11, (1116).

This species belongs to the controversial *Laestadia*-*Guignardia*-*Gnomonina* group, whose involved historical background has been reviewed by Höhnelt (5), Sydow (12) and Miller and Thompson (9). Miller and Thompson conclude their remarks with the following words: "The writers of this paper will follow Petrak in considering *Sphaerella Bidwellii* the type of *Guignardia*, and so re-

strict the genus to forms with uniloculate stromata, with no beak, fasciculate asci, no paraphyses and one-celled ascospores" The genus name *Guignardia* is used here in this sense. Nevertheless, the writer believes this to be a make-shift solution. He is strongly inclined to Sydow's view that Viala and Ravaz' real intentions were the substitution of the name *Guignardia* for the name *Laestadia*, and that they had no right and no intention to present *Guignardia Bidwellii* as a type, for if this species were congeneric with *Laes-*



FIGS 13-20 Wyoming *Pyrenomyces*

*tadia alnea*, it obviously could not be the type, and if it were not congeneric, they would obviously be erecting a new genus, with *G. Bidwellii* as a type, and not a substitute name. This view makes *Laestadia*, *Guignardia*, and *Gnomonina* synonymous, but leaves no name for the group here considered (including *G. Bidwellii*?). Hohnel's conclusions cannot be taken as final. He never saw *G. Bidwellii*, which is apparently not a *Phyllachorella*. A comparative study of the types of *Laestadia*, *Phyllachorella*, *Montagnellina*, *Haplothecium*, *Laestadiella* and other genera must be made before this question can be resolved.

## HERPOTRICHIA QUINQUESEPTATA Wier

The ascospores of this material are light yellow-brown, 5-septate,  $25-28 \times 7-8 \mu$ , and the spores and asci are identical with figures given by Wier (14).

Medicine Bow Mts., Laramie, Wyo.: on *Picea Engelmanni* (Parry) Engelm., June 15 (1009).

## HYPODERMELLA CONCOLOR (Dearn.) Darker

Hysterothecia sunken, walls colorless,  $300-400 \times 200-250 \mu$ . Asci clavate, with a tapered base,  $85-110 \times 14-16 \mu$ . Paraphyses filiform, numerous. Spores clavate-fusoid, rounded at one end, tapered toward the other,  $40-44 \times 2.5-3.5 \mu$ , with a gelatinous envelope  $3 \mu$  thick when first emitted from the ascus.

On *Pinus Murrayana* Balf., Camp Davis, June 17 (1004).

The association of fungi on these needles is an interesting but confusing one. The *Hypodermella* appears on the upper surface of leaves of the previous year, as small papillae, or later, as small sunken watery spots, with a minute central ostiole. These needles have dry, brown, discolored tips, but the hysterothecia are scattered on and concolorous with the green living portions. The colorless hysterothecia place this collection in the group of related species including *H. sulcigena* (Rostr.) Tuh., *H. montivaga* (Petr.) Dearn. and *H. concolor* (Dearn.) Dark. It is placed in the last species because of the small hysterothecia, although the spores are smaller than given for that species ( $45-60 \times 6-8 \mu$ ) by Darker (2).

On these same living needles, there occurs a *Hendersonia* (sp.) which appears to be parasitic and is very similar to *H. acicola* Münch. & Tuh. It is of interest in this connection that Lagerberg's (6) contention that *H. acicola* is the conidial stage of *H. sulcigena* has been accepted by most European workers, whereas Darker (2: 56) states that "From observations made in western America on the closely related species, *H. montivaga*, the writer believes that *Hendersonia* is merely a secondary fungus following up after the disease has been initiated by the other species." Darker gives no notes of the *Hendersonia* concerned. This view of Darker's is borne out to some extent by the occurrence on the same infected needles of other fungi of a secondary nature. *Myco-*

*sphaerella Hypodermellae* is found on these same needles, and its conidial stage (?), a *Scolecotrichum* (FIG. 10), is found parasitizing the hysterothecia of the *Hypodermella*. In addition, a few minute pycnidia (50–70  $\mu$  in diameter) of a *Ramularia*, with long cylindric, straight to curved, 4-celled, hyaline conidia,  $19\text{--}30 \times 2\text{--}2.5\mu$  were found parasitizing these same hysterothecia. It is obvious that the *Hypodermella*, which supposedly was the primary infection, so weakens the needles, that a number of secondary fungi gain entrance.

#### LOPHODERMIVM NITENS Darker

Glory Mt.: On *Pinus flexilis* James, June 20 (1030).

#### METASPHAERIA JUNCINELLA Mout. (FIG. 16)

Appearing on the stems as widely but evenly scattered, minute, black dots, which are the globose immersed perithecia, 100–200  $\mu$  in diameter, with walls 5–10  $\mu$  thick, of coarse dark pseudoparenchyma; ostiole pore-like. Asci few, saccate to broad-clavate, with a thickened wall and a claw-like base,  $50\text{--}70 \times 18\text{--}20\mu$ . Spores crowded fasciculate, cylindric, straight or slightly curved, hyaline to pale yellowish, triseptate, sometimes slightly constricted at the central septum, and often with a terminal, globose appendage when released from the ascus,  $32\text{--}41 \times 5\text{--}5.5\mu$ .

Elk Refuge, Jackson, Wyo.: on stems of *Scirpus validus* Vahl, July 1 (1071a).

This material is rather immature and it is possible that the spores may become darker in color and so place it in *Leptosphaeria*. It is very similar to *L. juncicola* Rehm. It differs from the description of *Metasphaeria juncinella*, however, only in the shorter and stouter asci, but these asci often elongate with maturity, and it is placed here until further material can be examined. The perithecia are accompanied by a *Phaeoseptoria* (sp.), which has slightly larger and more widely spaced pycnidia.

**MYCOSPHAERELLA:** The custom of describing species upon the basis of host occurrence leaves very little meaning to species names in this group of saprophytic stem inhabiting fungi, where host limitation has not been demonstrated.

The intention in this paper is to arrange the material in such a way that it is available for later reference, rather than to bury it

beneath the names of a number of new species or misdeterminations. To that end, the collections have been arranged in Table I according to spore size, and lines are used to separate probable species groups, the differential characters of which are elaborated upon in the text descriptions. In Table II a large number of collections, showing certain characters in common, are similarly arranged and placed under the collective species *Mycosphaerella Tassiana* (de Not.) Johans.

TABLE I

No.	Host	Spore Range	Asci	Perithecia
1067	PEDICULARIS	8-10×2-2.5	25×7	100-200
1131c	CLEMATIS	10.5-11.5×2.5	37-43×7	100-125
1112c	CARUM	10.5-16×3-3.5	35-40×7	
1113	ERIGERON	12-13×3-4	44-53×7-9	100-150
1056	AQUILEGIA	12.5-15×3-3.5		
1180	AQUILEGIA	12.5-16×3.5	36-38×11-14	100-150
1114	AQUILEGIA	16-18×3.5	45-55×9-10.5	100-150
1045a	DELPHINIUM	12.5-18×3.5-5	50-60×12.5-16	
1024a	COMPOSITUM	14-18×3.5-4.5	45-53×9-11	150-200
1129	DELPHINIUM	14-18×3.5-4.3	53×10.5-12.5	150-200
1004b	PINUS	13-16×3.5-5	70-90×17-21	90-100
1072	JUNCUS	14-18×2.5-3.5	30-35×8-12	40-50
1124	CLEMATIS	22-30×2.5-3.5	50-55×12-13	100-150
1131	CLEMATIS	29-35×3-3.5	55-70×9-12	150-200
1166	CARUM	30-40×2.5-3.5	62-70×14	120-150
1026c	UMBELLIFER	32-37×3-3.5	60-75×14-15	200
1112b	CARUM	33-37×3-3.5	53-61×14-16	120-150

There is much variation as to spore size with degree of maturity, the amount of subepidermal or superficial hyphal growth, form and distribution of perithecia, etc., but it is often impossible to demonstrate any correlation with host occurrence. The separation and naming of species has, therefore, been somewhat arbitrary. Names of previously described species have been applied wherever practicable.

*MYCOSPHAERELLA TASSIANA* (de Not.) Johans. (FIGS. 5, 6 & 9).

Camp Davis: On *Glycyrrhiza lepidota* Pursh, Snake River Canyon, July 15 (1140); *Senecio Rydbergii* A. Nels., June 19 (1033); *Comandra pallida* DC. (1011); *Heuchera Williamsii* Eaton, June 24 (1044); *Castilleja linariaefolia* Benth.,

TABLE II

No.	Host	Spore Range	Asci	Perithecia
1140	GLYCERRHIZA	12-16×2-5	43-68×12-14	100-150
1089a	PENSTEMON	12.5-14×3.5	53×17.5	
1159c	CASTILLEJA	14-15×5	35-43×16-18	90-100
1101a	LUPINUS	14-17×4.3-5.3	55-70×19-21	100-150
1015a	CASTILLEJA	14-18×4.5-5	55-65×16-17	100-130
1119	OSMORRHIZA	14-18×3.5-5	55-70×14-18	100-140
1142	BUPLEURUM	14-22×5-6	43-60×17-23	
1044	HEUCHERA	14.5-18×5-6	27-45×15-20	50-100
1115	THALICTRUM	(14) 17-22×3.5-7	35-43×20-23	100-120
1022d	UMBELLIFER	16-18×5-6	70×10	
1032a	SYNTHESIS	16-18×4-5.5	43-60×17-22	100-120
1126f	HEDYSARUM	16-18×3.5-5	43-53×11-22	
1064	HELIANTHELLA	16-19×5-5.5	50-53×10.5-18	100-150
1134d	LINUM	17-19×5-6	60-70×21	150-200
1025b	BALSAMORRHIZA	17-20×4-5	70-80×12.5-18	100-150
1033	SENECIO	17-20×5-6	50-60×19-23	100-120
1133c	SAMBUCUS	17-20×5-6	62×21.5	
1011	COMMANDRA	17.5 19.5×5-7	53-65×22	
1114a	AQUILEGIA	17-22×5-5.5	35-40×23-25	90-120
1108c	RUDBECKIA	17-23×5	62×18	
1121h	AGASTACHE	18-20×3.5-4.5	63-70×18-20	100-120
1128b	VALERIANA	18-21.5×5.3-7	53-70×22	
1212	SISYRINCHIUM	18-23×5.3-7	40-53×18	80-100
1100c	HELIANTHELLA	19-23×5.5-6	55-65×18-21	
1166f	CARUM	19-23×7	70-78×18-26	150-200
1109	AGASTACHE	20-22×4-5.5	70-75×17-27	100-150
1167a	LINUM	21×7	97×21	80-100
1185b	DRABA	21-22×5	60×17-19	100-150
1016	PENSTEMON	21-24×5-7	70×18	100-120
1023a	LINARIA	21.5-23×5-5.5	70×23-25	
1177a	SENECIO	26.5-28.5×5.5-8.5	60-70×22-26.5	150

Hoback-Snake River Junction, July 15 (1159c); *C. flava* Wats., June 18 (1015a); *Penstemon glaber* Pursh, June 18 (1016); *Sisyrinchium angustifolium* Miller, June 18 (1212); *Balsamorrhiza sagittata* (Pursh) Nutt., June 26 (1063b); *Linum Lewisii* Pursh, June 24 (1047a) and *Helianthella quinquecrevis* (Hook.) Gray (1064).

Cream Puff Mt.: On *Penstemon Rydbergii* A. Nels., July 5 (1089a).

Hoback Canyon: On *Bupleurum americanum* C. & R., July 16 (1142); *Aquilegia coerulea* James, June 25 (1056b) and *Draba luteola* Greene, Red Creek, July 29 (1185b).

Glory Mt.: June 20, on *Syntheris dissecta* Rydb. (1032a); *Balsamorrhiza sagittata* (Pursh) Nutt. (1025b) and *Linaria vulgaris* Mill. (1023a).

South of Teton Pass: July 11, on *Osmorrhiza occidentalis* Torr. (1119); *Agastache urticifolia* (Benth.) Rydb. (1109 & 1121h); *Aquilegia coerulea* James (1114a); *Thalictrum occidentale* Gray (1115); *Sambucus microbotrys* Rydb. (1133c); *Pedicularis contorta* Benth. (1135a); Umbellifer stems (1022d); *Lupinus parviflorus* Nutt. (1110f & 1130c); *Rudbeckia occidentalis* Nutt. (1108c); *Hedysarum Uintahense* A. Nels. (1126f); *Valeriana* sp. (1128b) and *Linum Lewisii* Pursh (1134d).

Togwotee Pass: July 8, on *Helianthella* (?) (1100c) and *Lupinus candicans* Rydb. (1101a).

Skyline Trail: July 24, on *Linum Lewisii* Pursh (1167a); *Zygadenus alpina* Blak. (1176b); *Aconitum Bakeri* Greene (1169a); *Scnecio* sp. (1177a); and *Carum Carni* L. (1166f).

In Table II the spore, ascus and perithecial measurements are given of a large number of collections which form a species complex with a good deal of variation, but with certain characters in common. This represents an extremely widespread arctic-alpine species complex which has been reported under this or other binomials on a wide variety of hosts in every flora of the fungi of northern regions or high altitude. It is the most abundant species on stems in Wyoming, and scarcely a collection can be made without its yielding a representative of this group.

The perithecia are all small, 70–150  $\mu$  (rarely 200  $\mu$ ) in diameter, and are globose at first, but soon become characteristically pyriform because of the formation of a rather stout conic ostiole. They may be, on the other hand, widely scattered, densely crowded or confluent, and may or may not show a blackening of the host surface. They are immersed at first but later become strongly erumpent.

The shape of the ascus is perhaps the most diagnostic character of the group. Typically, it is broadly saccate below and is contracted sharply into a narrower cylindric tip which has a much thickened wall (FIGS. 5–6). The spores are crowded in the lower broader portion. With maturity, however, the ascus may stretch and become more regularly clavate or even cylindric.

The spores are also quite variable, as can be seen from Table II. They are narrow-fusoid and slightly constricted at first, but become broader clavate or wedge-shaped, with the upper cell broad and rounded and the lower one narrower and tapered, and with no constriction. The smaller spores (below  $14\ \mu$ ), on *Glycyrrhiza* and *Penstemon*, are immature.

The writer agrees with Lind (7: 164) that this is a collective species, with many synonyms, which has been reported on many hosts under many binomials. Some authors use the above binomial for the occurrences of this fungus on Monocotyledons and the name *Mycosphaerella pachyasca* (Rostr.) Vestergr. for its occurrences on Dicotyledons. Lind, however, unites the two usages under the earlier name, which seems logical until more definite information is available as to possible subdivisions of this complex.

The writer also agrees with Winter (15: 359) that it is difficult to draw lines between this and other species because of the variability of its characters and the overlapping variations found on a series of hosts, which is strikingly portrayed by the series in Table II.

The collection on *Heuchera*, for instance, is probably the same as *Sphaerella trichophila* (Karst.) var. *Saxifragae* Dearness of which Dearness (3: 346) says "This *Sphaerella* has characters connecting it with *S. minor* Karst. and *S. pachyasca* Rostr. . . . But the bristles near the vertex, the brown subiculum and the fruit characters bring it closer to *S. trichophila*." *S. trichophila* is given as having the spores and asci of *S. Tassiana*, and the other characters mentioned are commonly associated with this species complex. No. 1119, on *Osmorrhiza* (*Glycosma*) *occidentalis*, is probably the *Mycosphaerella Glycosmae* of Tracy & Earle. *M. Washingtoniae* Rehm (10: 346), although reported on *Palmae* by Saccardo (Syll. Fung. 24: 881), is described on *Washingtonia brachypoda* and seems to be a synonym. The large spored form, on *Penstemon*, may be *Mycosphaerella Penstemonis* Tracy & Earle.

The perithecia are often accompanied by a *Scolecotrichum*-like growth of upright, zigzag, septate, brown hyphae, or by scattered or densely crowded pycnidium-like sclerotia, which may be sterile perithecial primordia, and which are crowned by a fascicle of stiff,



upright, septate, brown hyphae, 3–5  $\mu$  in diameter. Either on these conidiophores, or on the setose hyphae of the sclerotia, there are borne two-celled, brown, oblong-cylindric conidia, 17–22  $\times$  7  $\mu$ , which arise singly and sparingly at the apex of these hyphae. The hypha then grows on and produces another conidium. These conidia are very seldom seen attached, but are usually deciduous onto the host surface. In the collection on *Osmorrhiza* (No. 1119), similar setose sclerotia were seen, but here fusoid-cylindric, curved, hyaline conidia, 25–35  $\times$  3–4  $\mu$ , and similar to those reported under *M. dolichospora*, on umbelliferous hosts, were found. Similar *Scolecotrichum* or sclerotial conidial stages were found associated with several other species of *Mycosphaerella* and seem to be characteristic of the stem forms of this genus. Their cultural connection would be of interest.

*MYCOSPHAERELLA PUNCTIFORMIS* (Fr.) Starb. var. *CLEMATIDIS* Jaap.

Perithecia minute, globose, 100–125  $\mu$  in diameter, thickly scattered on crowded, usually limited, blackened areas caused by the subepidermal growth of dark brown hyphae; ostiole stout, papillate not prominent. Asci clavate, usually emitted in a ball-like fascicle, apical wall thickened, 25–43  $\times$  7  $\mu$ . Spores biserial, fusoid-ellipsoid, one end sometimes more rounded, two-celled, hyaline, scarcely constricted at the septum, 8–14 (16)  $\times$  2–2.5 (3.5)  $\mu$ .

South of Teton Pass: July 11, on *Erigeron salsuginosus* Gray (1113), *Carum Carui* L. (1112c) and *Clematis Douglasii* Hook. (1131c).

Camp Davis: Willow Creek, June 28, on *Pedicularis groenlandica* Retz. (1067).

This is admittedly a provisional grouping of these four collections, which show small, fusoid spores, clavate asci and clustered perithecia with a development of dark colored, radiate subepidermal hyphae. There is rather a wide range of spore size, but more data are needed before these differences can be correlated for species differentiation. This variety seems to be the most similar to my collections of any described on these hosts. *M. vitalbina* (Pass.) Petr. is also similar but is described with asci inflated at the base, suggesting a young stage of *M. Tassiana*. *Sphaerella*

*Pedicularis* Karst., *S. lineata* (Clem.) Sacc. & Sacc. and *S. subcongregata* E. & E. also seem to be *M. Tassiana*. The collection on *Carum*, which has the larger spores ( $10-16 \times 3-3.5 \mu$ ), comes closest to *Sphaerella sagedioides* Winter of any of the species described on Umbelliferae.

#### MYCOSPHAERELLA COERULEA (E. & E.) Tracy & Earle

Perithecia sparsely to thickly, but evenly scattered, usually with no, or very little blackening of the substratum, immersed then erumpent by a minute ostiole, black, globose, to somewhat flattened,  $100-150 \mu$  in diameter. Asci stout clavate, with a thickened apical wall, fasciculate,  $35-44 \times 7-14 \mu$ . Spores biseriate, fusoid-ellipsoid, two-celled, hyaline, slightly constricted at the septum,  $12.5-18 \times 3-3.5 \mu$ .

On *Aquilegia coerulea* J. A. Jones, South of Teton Pass, July 11 (1114); Red Creek, Hoback Canyon, July 29 (1180) and at Hoback Forest Camp, June 25 (1056).

*M. coerulea* is given with slightly larger spores ( $15-20 \times 3.5-4.5 \mu$ ), but Ellis, N. A. F. No. 3522 of *Sphaerella coerulea*, is identical with these collections and shows spores  $13-18 \times 3.5-4 \mu$ . This species differs from *M. Tassiana*, which occurs on the same stems, in the more evenly distributed, shiny black, more globose to depressed perithecia and the clavate asci and fusoid spores.

#### MYCOSPHAERELLA DELPHINIICOLA Earle

Perithecia  $150-200 \mu$  in diameter, globose, sparsely or densely scattered, sometimes with a slight amount of radiating subepidermal, brown hyphae. Asci clavate, with a somewhat thickened apical wall,  $43-60 \times 9-16 \mu$ . Spores biseriate, fusoid-ellipsoid, two-celled, hyaline, constricted at the septum,  $12.5-18 \times 3.5-5 (6) \mu$ .

On *Delphinium Brownii* Rydb., Camp Davis, June 24 (1045a) and South of Teton Pass, July 11 (1129); and on some composite, Glory Mt., June 20 (1024a).

These collections on *Delphinium* are very similar to those of *M. coerulca*, but slightly larger throughout, with more dark creeping hyphae. *M. delphiniicola* is given with smaller spores ( $12 \times 3 \mu$ ), but is used provisionally as the spores may have been immature.

In No. 1045a, a *Scolecotrichum*-like conidial stage was seen, consisting of upright, somewhat geniculate, septate, brown conidiophores,  $50-125 \times 3.5-5 \mu$ , which arose from the upper walls of the perithecia or from sterile primordia as in *M. Tassiana*. No conidia were seen attached, but several minute sterigmata could be seen on the light colored tips of the conidiophores and deciduous conidia on the host surface were oblong-cylindric, brown, usually two-celled but becoming four-celled, and (12.5)  $16-20 \times 7-9 \mu$ . The walls of these conidia were smooth at first, but became finely echinulate at maturity.

***Mycosphaerella dolichospora* (Sacc. & Fautr.) comb. nov. (FIGS. 11-12)**

*Sphaerella dolichospora* Saccardo & Fautrey, Rev. Myc. 1897, p. 143.

Perithecia thickly scattered or densely clustered, usually on somewhat elongate or widespread areas which are blackened by a growth of stout dark brown, branched hyphae, globose to somewhat conic with a stout ostiole,  $100-200 \mu$  in diameter, rather prominently erumpent, with thick ( $18-36 \mu$ ) walls of coarse black parenchyma. Asci stout clavate, with a thickened apical wall,  $50-70 \times 10-16 \mu$ . Spores fasciculate in the ascus, fusoid-cylindric, straight or slightly curved, two-celled, hyaline, slightly constricted at the septum, (22)  $25-40 \times 2.5-3.5 \mu$ .

Glory Mt.: June 20, on Umbellifer stems (1026c).

South of Teton Pass: July 11, on *Clematis Douglasii* Hook. (1124 & 1131) and *Carum Carui* L. (1112b).

Skyline Trail: July 24, on *Carum Carui* L. (1166).

These collections are all similar in the long, narrow, fusoid, curved spores and the blackening of the host surface. There are a number of species of *Mycosphaerella* described with such spores, but they are mostly found on the leaves of woody plants. *Sphaerella dolichospora* Sacc. & Fautr. has its spores given as  $30-32 \times 4 \mu$  and seems to be most like these collections, all of which were made at high altitudes and on two distinct groups of host plants. The spores on *Clematis* ( $25-35 \mu$ ) run somewhat shorter than those on the Umbelliferae.

On both Nos. 1166 and 1026c, the perithecia of this species were associated with small conic to pyriform sclerotia (perithecial

primordia?) up to  $100\ \mu$  in diameter, which were surmounted by a fascicle of stiff, pointed, brown, septate hairs, up to  $150\ \mu$  long and  $7\ \mu$  in diameter (FIG. 12), very similar to the conidial stage described as associated with *M. Tassiana*. Here, however, conidia (FIG. 11) were found scattered or in small clumps, held within this apical fascicle of hairs. These conidia were cylindric-fusoid, hyaline, two-celled, curved, and  $35\text{--}46 \times 3\text{--}3.5\ \mu$ . Their method of attachment or formation could not be determined. The sclerotia seem to be solid masses of tissue without any cavities. It is possible that these spores are emitted ascospores, but they run somewhat larger in size and are more strongly curved. If borne within the sclerotia, the conidial stage would fall in the form genus *Vermiculariella*.

*MYCOSPHAERELLA PEREXIGUA* (Karst.) Johans. (FIGS. 7-8)

On *Juncus filiformis* L., Elk Refuge, Jackson, Wyo., July 1 (1072).

This species has asci similar to *M. Tassiana*. They are broadly clavate, usually broader at the base and narrowed toward the apex with a much thickened wall. The perithecia, however, are smaller ( $40\text{--}50\ \mu$ ) than in *M. Tassiana*, and are evenly scattered in grayish spots or areas. The spores remain fusoid ( $14\text{--}18 \times 2.5\text{--}3.5\ \mu$ ) instead of becoming clavate. It is another arctic-alpine species and is similar to *M. Wichuriana* (Schroet.) Johans., on sedges and grasses.

Lind (8: 18) says that *M. perexigua* is often associated with *Scptoria punctoides* Karst. Karsten gives the spores of his species as fusoid-bacillar and  $12\text{--}16 \times 1.5\text{--}2\ \mu$ . Lind (8: 36), on the other hand, in his report of this species gives the spores as cylindric, biseptate and  $24 \times 1\ \mu$ . It is such discrepancies which make one suspicious of many reports in the literature. The writer finds on these stems minute pycnidia,  $40\text{--}50\ \mu$  in diameter, which are more widely scattered than the perithecia of *M. perexigua* and which contain fusoid-cylindric, one-celled, hyaline conidia  $10\text{--}16 \times 2\text{--}3\ \mu$ . Although they would be better placed in *Phoma*, these pycnidia seem to be those of Karsten's *S. punctoides*.

Again, freely scattered on these stems there are similar patches of small dots, which upon examination prove to be a *Scolecotri-*

*chum* or *Brachysporium*. The punctate dots consist of small clusters of erect, septate, brown conidiophores arising from a knot of intertwined hyphae or from small sclerotia (perithecial primordia?) (FIG. 7). From the tips of these conidiophores there are cut off singly brown, ellipsoid conidia (FIG. 8) which are one-celled at first but may become 1-4 celled and variable in size with age, from  $7-21 \times 3.5-6 \mu$ . The walls are very finely roughened in some cases. This same conidial stage is found on *Scirpus* stems (1071) in association with a *Pleospora* and *Metasphaeria juncinella*.

***Mycosphaerella Hypodermellae* sp. nov. (FIG. 10)**

Perithecia globosa, 90-100  $\mu$  diametro, pariete crasse parenchymatoso, atro, 25-35  $\mu$  crasso, singulatim dispersa vel in lineas ordinata, in folii contextu immersa, ostiolis minutis per rimam communem erumpentibus. Status conidialis in folii superficie per rimas numerosas, 100-300  $\mu$  longas, lineares obviis, stromate setiformium conidiophorum 5-6  $\mu$  diametro praeditus. Asci fasciculati aggregati, late clavati, primum 70  $\mu$  longi, 21  $\mu$  crassi, aetate ad longitudinem 85-90  $\mu$ , crassitudinem 17-18  $\mu$  elongati. Sporae biseriatae, clavatae, ellipsoideae, bicellulae, hyalinae, 13-16  $\mu$  longae, 3.5-5  $\mu$  latae, apice rotundatae, basi angustatae.

Specimen typicum in foliis viventibus *Pinus Murrayanae* Balf. ad locum dictum "Camp Davis," Jackson, Wyoming, 17 Junii, 1940, legit L. E. Wehmeyer, sub numero 1004b.

Appearing on the surface of the needle as numerous elongate, linear ruptures of the epidermis, 100-300  $\mu$  in length, through which a minutely granular stroma or a linear cluster of upright setose hyphae are erumpent. Perithecia globose, 90-100  $\mu$  in diameter, with walls of coarse black parenchyma 25-35  $\mu$  thick, scattered singly or in linear series, immersed in the leaf tissue and erumpent by means of a minute papillate ostiole through a common rupture, often with a cluster of upright, spine-like conidiophore hyphae, 5-6  $\mu$  in diameter. Asci crowded fasciculate, broadly clavate,  $70 \times 21 \mu$  at first, elongating to  $85-90 \times 17-18 \mu$  at maturity. Spores biseriate, clavate-ellipsoid, two-celled, hyaline, upper end rounded, tapered toward the base,  $13-16 \times 3.5-5 \mu$ .

Camp Davis: June 17, on living needles of *Pinus Murrayana* Balf., leg. L. E. Wehmeyer (1004b) (Type).

The pustules of this fungus occur on the older somewhat discolored needles attacked by *Hypodermella concolor*. The dark brown, septate hyphae proliferate in the hysterothecia of this

fungus, or just beneath the epidermis of the leaf and form small stromatic masses from which arise the conidiophores of the *Scolecotrichum* stage. These are upright, brown, closely septate,  $5-7\ \mu$  in diameter and  $85-100\ \mu$  long. They bear brown, ellipsoid conidia which soon become two-celled and measure  $17-18 \times 7\ \mu$ . These conidia are deciduous and are seldom seen attached. Both the ascus and conidial stage are similar to *M. Tassiana*, but the asci in this species are more regularly clavate and the perithecia are more globose, and immersed in longitudinal rows. This collection comes closest to *M. Abietis* (Rostr.) Lind but Rostrup gives *Phoma Abietis* and *Toxosporium abietinum* as conidial stages of his species. *M. Peckii* (Sacc.), on hemlock cones, *M. Pinsapo* (Thüm.) and *M. pinicola* Fautr., on needles of fir and pine are also similar but have smaller spores.

#### NECTRIELLA PEDICULARIS (Tracy & Earle) Seaver

Glory Mt.: On *Umbellifer* stems, June 20 (1026).

South of Teton Pass: July 11, on *Linum Lewisii* Pursh (1134e).

Togwotee Pass: July 8, on *Pedicularis racemosa* Dougl. (1097).

This species is quite common on stems of many hosts at high altitudes. It appears as minute, orange to reddish, rounded, saucer-shaped spots, which are the immersed perithecia. It is commonly found in an immature condition. The perithecia are often scattered and occurred on many more of the collections than those here recorded, which were the only ones examined microscopically.

#### PHOMATOSPORA THEROPHILA (Desm.) Sacc.

Perithecia  $200\ \mu$  in diameter, appearing on the stems as black spot-like clusters, barely erumpent. Asci cylindric,  $44-55 \times 6-7\ \mu$ , with numerous paraphyses which are taper-pointed and guttulate. Spores oblique uniseriate, fusoid-ellipsoid, one-celled, hyaline,  $7-9 \times 2.5-3\ \mu$ .

On *Juncus filiformis* L., Elk Refuge, Jackson, Wyo., July 1 (1072a).

These are the largest of the many different pycnidia and perithecia intermingled on these stems.

## ROSELLINIA OVALIS (Ell.) Sacc. (FIG. 20)

Perithecia superficial, globose, carbonaceous, 200–300  $\mu$  in diameter, with a wall 25–50  $\mu$  thick, of fine brownish hyphae, and surrounded by an evanescent weft of brownish hyphae. Asci long cylindric, 90–125  $\times$  7–7.5  $\mu$ . Paraphyses broad band-like. Spores uniseriate, oblong-ellipsoid, somewhat flattened, with a longitudinal germ slit along the narrow side, 8.8–10.5  $\times$  6–7  $\times$  5–6  $\mu$ .

Camp Davis: July 4, on decorticated wood of *Salix* (1079).

The type, Ellis N.A.F. No. 896, of this species shows the same flattened spores with a germ slit on the narrow side. It differs only in the lack of the basal weft of hyphae, which may disappear.

**Sphaerulina Gentianae** sp. nov. (FIGS. 17–19)

Perithecia dispersa in foliis et caulibus, 400–500  $\mu$  diametro, globosa vel conica, basi applanata, sub epidermate formata, deinde erumpentia, superficialia, aetate irregulariter collapsa; ostiolo parvo, papilliformi; pariete parenchymatoso, intus hyalino, extus atro, crasso, contextu caulium circum perithecorum bases nigricanti. Asci cylindrici-clavati, 150–160  $\mu$  longi, 32–39  $\mu$  crassi, pariete incrassato. Paraphyses nulli. Sporae biseriatae vel uniseriatae, imbricatae, ellipsoideae, hyalinae, 46–54  $\mu$  longae, 14–16  $\mu$  crassae, primum bicellulae, deinde 4-cellulae, ad septum paulum constrictae, granulosa, in parte inferiore quam superiore angustiores, cellulis omnibus uniguttulatis.

Specimen typicum in foliis et caulibus *Gentianae calycosae* Griseb., secus viam "Skyline Trail," Teton National Park, Wyoming, 24 Julii, 1940, legit L. E. Wehmeyer, sub numero 1174.

Perithecia scattered on both leaves and stems, formed just beneath the epidermis, but soon erumpent, superficial, globose to conic, with a flattened base, 400–500  $\mu$  in diameter, causing a blackening of the tissue about the base, ostiole small papillate, wall thick (60–70  $\mu$ ), with an outer layer (20–30  $\mu$ ) of coarse black parenchyma and an inner hyaline layer which is much thickened below. Perithecia collapsing in an irregular wrinkled manner with age. Asci cylindric-clavate, 150–260  $\times$  32–39  $\mu$ , with a thickened apical wall. No paraphyses present. Spores biseriate to overlapping uniseriate, ellipsoid, hyaline, contained in an evanescent gelatinous envelope, two-celled at first, becoming four-celled at maturity, slightly constricted at the septa, contents granular with a large angular fat (?) body in each cell, 46–54  $\times$  14–18  $\mu$ . The lower half of the spore is often somewhat narrower than the upper.

Skyline Trail: On *Gentiana calycosa* Griseb., July 24, behind Grand Teton Peak (1174) (Type); and Aug. 5, at Overlook (1210).

Both these collections were found above 9000 feet elevation, on the same host and occur on both stems and leaves, indicating that it may be parasitic and so limited in its host range.

In the immature two-celled condition of the spores, it might easily be mistaken for a *Didymella* or *Massarinula*. In the four-celled condition, with the gelatinous envelope, the spores look very much like those of a *Massarina*. *Metasphaeria* and *Sphaerulina* are also possibilities. The lack of paraphyses and the erumpent-superficial habit on both stems and leaves seem to place it in the latter genus. There seems to be no such fungus described in any of these genera.

***Sphaerulina inaequalis* sp. nov. (FIG. 15)**

Perithecia dense dispersa, immersa deinde erumpentia, depresso globosa, 180–250  $\mu$  diametro; ostiolo centrali, papilliformi; pariete parenchymatoso, crasso, atro. Asci clavati, 50–75  $\mu$  longi, 14–15  $\mu$  crassi; ad basin attenuati, quando vacui collapsantes sed persistentes. Paraphyses nulli. Sporae biseriatae, fusiformiter ellipsoidales, inaequilaterales vel paulum curvatae 18–25  $\mu$  longae, 3.5–4  $\mu$  crassae, tricellulares, interdum ad septa paulum constrictae; cellulis exterioribus quam interiore brevioribus.

Specimen typicum in caulibus vetustis *Hedysari uintahensis* A. Nels., prope Teton Pass, Jackson, Wyoming, 11 Julii, 1940, legit L. E. Wehmeyer, sub numero 1126e.

Perithecia rather thickly scattered, immersed beneath the epidermis, then erumpent, flattened spheric, with a central papillate ostiole, 180–250  $\mu$  in diameter, with a wall 20–30  $\mu$  thick and composed of coarse black parenchyma. Asci clavate, with a tapered base, 50–75  $\times$  14–15  $\mu$ , wall collapsing when empty but persistent. No paraphyses present. Spores biseriatae, fusoid-ellipsoid, inequilateral to slightly curved, three-celled, with the two septa cutting off two short end cells and one longer central cell, sometimes slightly constricted at the septa, 18–25  $\times$  3.5–4  $\mu$ .

South of Teton Pass: July 11, on *Hedysarum uintahense* A. Nels., leg. L. E. Wehmeyer (1126e: type).

This species is characterized by the bisepitate, unequally three-celled spores. The asci collapse when empty, but persist as a wrinkled membrane. The absence of paraphyses places this spe-



cies in *Sphaerulina* rather than *Metasphaeria*. Intermingled with the perithecia, there were found pycnidia of an *Apiocarpella* (sp.).

*STRICKERIA OBDUCENS* (Fr.) Wint.

Perithecia thickly scattered, superficial on the blackened wood surface, globose, 400–500  $\mu$  in diameter, with a minute papillate ostiole, wall 40–100  $\mu$  thick, of small flattened pseudoparenchyma. Asci long cylindric, 130–140  $\times$  15–16  $\mu$ . Paraphyses present only as interthecial strips which disappear at maturity. Spores oblique uniseriate, fusoid-ellipsoid, brown, 5–7 septate, constricted at the central septum, with one vertical septum in several, but usually not all, of the middle cells, 23–30 (32)  $\times$  9–10.5  $\mu$ .

Camp Davis: June 18, on decorticated *Comimandra pallida* DC. stems (1011a).

This collection is more or less intermediate in its measurements between *S. obducens* and *Teichospora megastega* E. & E.

*SPORORMIA AUSTRALIS* Speg.

Hoback Forest Camp: on horse dung, July 22 (1232).

There are a number of species of *Sporormia* described with 4-celled ascospores similar to those of this collection. The papilli-form ostioles and the measurements of the spores (35–40  $\times$  6–7.5  $\mu$ ) and asci (90–130  $\times$  10–17  $\mu$ ) of this species, however, make it most similar to Cain's (1) description of *S. australis*.

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## DESCRIPTION OF FIGURES

(All spores are drawn to a scale of approximately 1 mm. equals 1  $\mu$ )

- FIG. 1. Vertical section of perithecium of *Apiosporella Mimuli* sp. nov.
- FIG. 2. Ascospores of *Apiosporella alpina* sp. nov.
- FIG. 3. Ascospores of *Apiosporella Mimuli* sp. nov.
- FIG. 4. Ascospores of *Didymella Castillejae* sp. nov.
- FIG. 5. Typical ascus and ascospores of *Mycosphaerella Tassiana* (de Not.) Johans. from collection on *Castilleja* (1159c) showing smaller size range.
- FIG. 6. Typical ascus and ascospores of *Mycosphaerella Tassiana* (de Not.) Johans. from collection on *Agastache* (1109) showing larger size range.
- FIG. 7. Scolecotrichum-type of conidial stage found associated with *Mycosphaerella perexigua* (Karst.) Johans.
- FIG. 8. Conidia of *Scolecotrichum* stage associated with *Mycosphaerella perexigua* (Karst.) Johans.
- FIG. 9. Type of conidial stage found associated with *Mycosphaerella Tassiana* (de Not.) Johans., showing conidiophores borne on sclerotia (left) and in fascicles (right) and two-celled conidia.
- FIG. 10. Section through needle of Pine infected with *Mycosphaerella Hypodermellae* sp. nov. a, perithecia in old hysterothecial cavities of *Hypodermella concolor* (Dearn.) Darker. b, empty infected *Hypodermella* cavities. c, Conidiophores and conidia formed from mycelia proliferating on such cavities.
- FIG. 11. Conidia found associated with *Mycosphaerella dolichospora* (Sacc. & Fautr.) comb. nov.
- FIG. 12. Setose sclerotia, bearing conidia, among the setae, and found associated with *Mycosphaerella dolichospora* (Sacc. & Fautr.) comb. nov.

- FIG. 13. Vertical section of perithecium of *Guignardia Epilobii* (Wallr.) comb. nov.
- FIG. 14. Ascospores of *Guignardia Epilobii* (Wallr.) comb. nov.
- FIG. 15. Ascospores of *Sphaerulina inaequalis* sp. nov.
- FIG. 16. Ascospores of *Metasphaeria juncinella* Mout.
- FIG. 17. Vertical section of perithecium of *Sphaerulina Gentianae* sp. nov.
- FIG. 18. Ascus and ascospores of *Sphaerulina Gentianae* sp. nov.
- FIG. 19. Ascospores of *Sphaerulina Gentianae*, with gelatinous envelope which is present when first released from the ascus.
- FIG. 20. Ascospores of *Rosellinia ovalis* (Ell.) Sacc., showing germ slits.

## **STUDIES IN THE GASTEROMYCETES XIII THE TYPES OF MISS WHITE'S SPECIES OF TYLOSTOMA**

W. H. LONG

(WITH 4 FIGURES)

When I began an intensive study of the genus *Tylostoma* a special effort was made to locate the types of the species published by Miss White (1901), since it was found necessary to examine them in order to be certain just what species she really had. This was especially desirable as much of my *Tylostoma* material came from the southwestern states and several of her species were based on specimens from this region.

I wrote to those herbaria which might have her types but was unable to locate them with the possible exception of material deposited in the New York Botanical Garden, which was the logical place for them to be. Dr. Seaver very kindly made several extended searches through the *Tylostoma* material there, but was unable to find anything specifically marked as Miss White's types. However, by a process of reasoning he was able to locate all her types inferentially. By locating specimens that corresponded to her data on collector, where collected, and her description of each species, he found what is undoubtedly the type material used by her in writing her article although there was nothing on the individual specimens to show that she had ever touched them. Apparently she wrote her descriptions for each of her new species, leaving the changing of the labels on the collections to a later date, which never came. As an illustration, *Tylostoma albicans* is recorded by her from Texas, Collector E. D. Cope. A collection by Cope from Texas was found and was the only material that she could have used. Since her description of *T. albicans* corresponds to this particular collection it is considered the type material. This process was repeated for her other species, and I am sure that the collections listed below are parts, if not all, of her type material for each. In the redescriptions which follow, the original legend

found with each collection is given, also the number and condition of the plants in it, and a redescription of the species is made from these type specimens.

TYLOSTOMA ALBICANS WHITE: TYPE FROM THE NEW YORK  
BOTANICAL GARDEN

Original legend: "*T. mammosum* Quélet, Texas, 1893, E. D. Cope." This collection consists of three loose sporocarps and six pieces of stems, two of these pieces have bases. *Sporophore* consisting of sporocarp, stipe and slightly bulbous base. *Sporocarp* depressed-globose, 5–7 mm. tall by 10–13 mm. wide; apparently rather loosely attached to stem apex. *Exoperidium* a sand case, completely deciduous on two plants and mostly so on the third. *Peridial sheath* a narrow band of hyphae and sand beneath sporocarp, 2–4 mm. wide, mainly persistent. *Endoperidium* thin, membranous, pinkish buff to cartridge buff to dingy white. *Mouth* small, tubular, tube very short, circular to oval, 1–2 mm. across. *Collar* inconspicuous, 2–3 mm. distant from stem. *Stipe* broken up and length not ascertainable, even, 3–5 mm. thick, brittle, with small, cartridge buff to dingy white, lacerate, appressed scales; two have disjointed sporocarps. *Bulb* 3–5 mm. thick with a trace of volva having pieces of stem cortex inside on one stem. *Radicating base*: none. *Gleba* cinnamon. *Capillitium* hyaline, branched, lumen small, 4–7  $\mu$  thick, septa not seen. *Spores* subglobose, 5–6  $\mu$ , some apiculate. *Epispore* smooth to verruculose.

TYPE LOCALITY: Texas.

HABITAT: apparently in unshaded areas and not in leaf debris as there was no debris left on bases of stems.

TYLOSTOMA POCULATUM WHITE: FROM LLOYD NO. 33642.  
PART OF TYPE

Original legend: "*Tylostoma poculatum* White, Long Pine, Nebraska, Feb. 3, 1896, J. M. Bates, Type specimens." This collection consists of three loose sporocarps, two with pieces of attached stems but bases gone, and six fragments of stems, two of these fragments being detached bases. *Sporophore* consisting of sporocarp, stipe and slightly bulbous base. *Sporocarp* subglobose,

4-6 mm. high by 8-10 mm. in diameter, firmly attached to stem apex but easily breaking off in or near the socket but not disjointed. *Exoperidium* strongly and permanently membranous, drying into a thin fragile envelope, soon deciduous in flakes and often leaving lacerate shreds of dried membrane around top of peridial sheath. *Peridial sheath* a thick band of agglutinated hyphae and sand, 4-6 mm. broad, often with a somewhat cup-shaped flaring upper margin. *Endoperidium* perfectly smooth, tillu-buff, membranous. *Mouth* with a fibrillose mat peristome, small fibrils slowly wearing away. *Collar* inconspicuous, close to stem. *Stipe* short, 1.5-2 cm. tall by 3 mm. thick, even, wood brown, wall's very thin and fragile, easily breaking—especially near the sporocarp. *Volva* and *radicating base* none; *base* slightly bulbous. *Gleba* light buff. *Capillitium* hyaline, sparingly branched, septa rare, swollen, 4.2-7  $\mu$  thick, lumen small to none. *Spores* 4.2-5.6  $\mu$ , subglobose, tinted. *Epispore* smooth, tinted, wall 1  $\mu$  thick.

TYPE LOCALITY: Long Pine, Nebraska. (Not "Lone" Pine as published.)

TYLOSTOMA MINUTUM WHITE: TYPE FROM NEW YORK  
BOTANICAL GARDEN

Original legend: "*Tylostoma obscurum* C. & E. Dwarf variety, Colorado, Bethel No. 22a." This collection consists of three plants, two with pieces of stems attached and a loose sporocarp with a very short stem. *Sporophore* consisting of sporocarp and stipe, no bases present. *Sporocarp* subglobose, 6-10 mm. tall by 8-12 mm. wide, firmly attached to stem apex but easily breaking off near socket. *Exoperidium* plainly membranous, early and completely deciduous on these three plants. *Peridial sheath* persistent, a thick band of hyphae and sand, 3-5 mm. wide. *Endoperidium* perfectly smooth, thin, membranous, two of sporocarps fawn color the remaining head a lighter color (vinaceous buff). *Mouth* fibrillose, raised, seated in a slight depression, circular, not open on the two large plants, but a slight pin hole present in the peristome of the smaller light-colored plant, fibrillose; peristome 3 mm. across, slightly darker than the endoperidium on the two large plants but concolorous with the endoperidium on the smaller

plant. *Collar* inconspicuous, close to stem, 1–2 mm. distant. *Stipe* (the fragments about 1 cm. long) even, terete, walls thin and weak, easily breaking, light brown (wood brown) or a slightly lighter color on one, slightly striate next to head on one. *Gleba* cinnamon rufous. *Capillitium* hyaline, sparingly branched, septa rare, slightly swollen 4–7  $\mu$  thick, lumen small. *Spores* subglobose, 4–5.6  $\mu$ , 1-guttulate, a few apiculate, tinted. *Epispore* mostly smooth, a few verruculose.

TYPE LOCALITY: Colorado. This species is based on young freshly emerged plants as evidenced by the unopened mouths and the darker endoperidia, characters common to *T. poculatum* in same stage of growth. According to Long (1946), *T. minutum* is a synonym of *T. poculatum*, both having all their major characters identical.

TYLOSTOMA TUBERCULATUM WHITE: TYPE FROM NEW YORK  
BOTANICAL GARDEN

Original legend: "*Tylostoma obesum* C. & E. British Columbia, Macoun." This collection consists of eleven sporocarps, four of them with short pieces of stems attached. *Sporophore* consisting of sporocarp and stems. *Sporocarp* subglobose to depressed-globose, 8–12 mm. tall by 10–15 mm. wide, easily separating from apex of stem usually by breaking at juncture of stem and apex. *Exoperidium* a granular sand coat, completely deciduous on all 11 heads. *Pecridial sheath* prominent, permanent, a heavy band of hyphae and sand under head, 4–5 mm. wide. *Endoperidium* light buff, smooth, tough, membranous. *Mouth* fibrillose, circular, raised, becoming somewhat enlarged and lacerate with age, but fibrillose mat still persisting around the enlarged orifice, peristome about 3 mm. in diameter, concolorous with the endoperidium. *Collar* inconspicuous, 1–2 mm. distant from stem. *Stipe* weak, easily breaking, apparently even, striate or slightly so, cinnamon color. Base of stems gone. *Gleba* hazel. *Capillitium* hyaline, 5–7  $\mu$  thick, much branched, septa rare and not swollen, lumen small. *Spores* subglobose, often irregular, 4.5–6  $\mu$ . *Epispore* smooth.

TYPE LOCALITY: British Columbia.

TYLOSTOMA SUBFUSCUM WHITE: TYPE FROM THE NEW YORK  
BOTANICAL GARDEN

Original legend: "*Tylostoma campestre* Morgan, Denver, Colorado, Feb. 16, 1896, Bethel No. 21." This collection consists of two plants, both with bases of stems broken off and gone. *Sporophore* consisting of sporocarp and stipe, originating 2 cm. below the surface of soil. *Sporocarp* subglobose, 10–12 mm. tall by 11–14 mm. wide, firmly attached to stem apex. *Exoperidium* a granular sand coat, completely deciduous on the two heads. *Peridial sheath* prominent, 3–5 mm. wide, persistent, a band of hyphae and dirt (not sand) beneath head. *Endoperidium* smooth, tough, dusky (light cinnamon drab to cinnamon drab), membranous, wrinkled. *Mouth* circular, prominent, raised, fibrillose, rather large, peristome 5 mm. across, mouth parts firm and not breaking up, mouths in these two plants not open, concolorous with endoperidium. *Collar* inconspicuous, close to stem,  $\frac{1}{2}$  to 1 mm. distant. *Stipe* even, terete, walls thin, lumen large, not very stout, slightly sulcate, pecan brown on one, the other covered with dirt, no signs of scales on either stem, base of stems on both plants broken off hence *bulb*, if any, gone. *Gleba* cinnamon. *Capillitium* hyaline, 5–6  $\mu$  thick, septa rare, slightly swollen, lumen small, sparingly branched. *Spores* subglobose, 4–5  $\mu$ , some apiculate. *Epispore* minutely verruculose.

TYPE LOCALITY: Denver, Colorado.

HABITAT: in clay soil judging by the dirt on stem.

TYLOSTOMA FIBRILLOSUM WHITE: TYPE FROM NEW YORK  
BOTANICAL GARDEN

Original legend: "*Tylostoma punctatum* Peck, sand dunes east shore of Lake Huron, Canada, September 1891, J. Dearness." This collection consists of one plant with sporocarp loose and stem broken in half. *Sporophore* consisting of sporocarp, stipe, and bulbous base, originating 3 cm. below surface of soil. *Sporocarp* subglobose, 12 mm. tall by 16 mm. wide. *Exoperidium* a granular sand coat, completely deciduous on this plant. *Peridial sheath* 5 mm. broad, prominent, persistent, a heavy band of hyphae and sand beneath head. *Endoperidium* white, smooth, tough, mem-



branous. *Mouth* a fibrillose thin mat, tough, parts not weak, slightly raised, elliptical, 3 mm. wide by 4 mm. long including peristome. *Collar* inconspicuous, about 1 mm. distant from stipe. *Stipe* stout, very slightly tapering to base, 6 cm. tall by 6 mm. thick at top and  $5\frac{1}{2}$  mm. at base, thick at base, walls thick, woody, about 2 mm., lumen small, curved in this specimen, terete, not fragile, expanding abruptly at base into a thin woody bulb which was enclosed with sand before too much handling, sulcate above, lower half was apparently covered with a layer of sand and hyphae, with a few strands of the mycelium still persisting, base of stipe white, flattened, with sand attached to bottom of the white disc, color of stipe pecan brown (not white as stated by author), with small appressed scales. *Bulb* persistent with a white flattish central core, still present, the core 6 mm. across. *Gleba* cinnamon rufous to ferruginous. *Capillitium* hyaline, lumen medium, ends rounded, septa rare, not swollen  $5-7\ \mu$  thick. *Sporcs* subglobose,  $5-6\ \mu$ . *Epispore* distinctly verruculose.

TYPE LOCALITY: East shore of Lake Huron, Canada.

HABITAT: on sand dunes along shores of lake.

TYLOSTOMA KANSENSE PECK IN WHITE: FROM NEW YORK  
BOTANICAL GARDEN

Original legend: "Kansas Fungi, collected by Elam Bartholomew, July 24, 1896, in hard bare soil, Rooks Co., Kansas, type material." This collection consists of a flattened sporocarp, remainder of plant destroyed by insects. I therefore had to supplement my description with data from other, but authentic material. Original legend on this supplementary material: "Kansas Fungi, collected by Elam Bartholomew, *Tylostoma kansense* vide Peck, in open cultivated soil, Rooks Co., Rockport, October 28, 1901," Lloyd No. 24729. This collection consists of six plants with sporocarps attached to stems, but with only two perfect stems with bases, also three pieces of stems, one piece with a base. *Sporophore* consisting of sporocarp, stipe and volva. *Sporocarp* subglobose, 1-1.5 cm. high by 1-1.5 cm. wide, firmly attached to stem apex, somewhat flattened beneath. *Exoperidium* a sand case, slowly deciduous. *Peridial sheath* a narrow band of agglu-

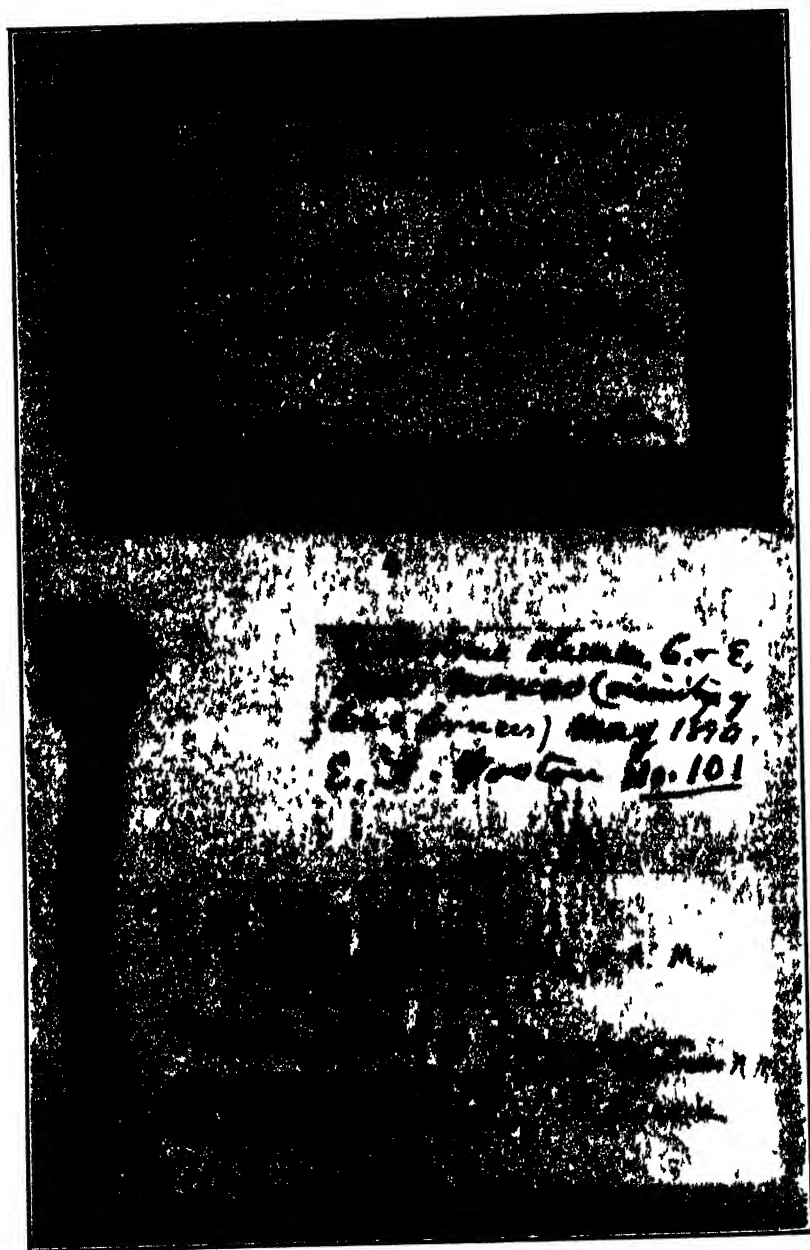
minated hyphae and dirt, persistent, 2–5 mm. wide beneath sporocarp. *Endoperidium* tough, membranous, white, with small particles of dirt here and there on surface. *Mouth* indefinite, an irregular lacerate orifice in these plants, naked, plane. *Collar* varied, short on some, 1–2 mm. distant from stem on others, pendant around stem for 2 mm., 1 mm. distant from stem, continuous with peridial sheath. *Stipe* stout, 1–5 cm. tall by 5–8 mm. thick, rugose, even, white, often longitudinally striate. *Volva* inconspicuous with pieces of stem cortex inside. *Base of stipe* slightly bulbous 4–5 cm. thick, sometimes radicating. *Gleba* cinnamon rufous. *Capillitium* hyaline to tinted, walls moderately thick, about  $1\ \mu$ , flexuous, uneven in thickness, ends rounded, short knob-like branches here and there, 4–5  $\mu$  thick, septa not seen, sparsely branched, constricted in places. *Spores* subglobose, subhyaline, 4.2–5  $\mu$  in dia., some  $4 \times 5\ \mu$ , uniguttulate, irregular in shape. *Epispore* about  $1\ \mu$  thick, subhyaline, smooth.

TYPE LOCALITY: Rockport, Kansas.

HABITAT: in open hardpan soil.

TYLOSTOMA GRACILE WHITE: TYPE FROM NEW YORK  
BOTANICAL GARDEN

Legends: See figures 2, 3 and 4, which are self explanatory. This collection consists of only one plant (FIG. 1) with mouth much lacerated. *Sporophore* consisting of sporocarp, stipe and very slightly enlarged base. *Sporocarp* depressed-globose, 1.2 cm. tall by 2 cm. wide. *Exoperidium*: none present. *Peridial sheath*: none present. *Endoperidium* thin, membranous, smooth, rather shining, cinnamon color. *Mouth* indefinite, plane, lacerate. *Collar*: none. *Stem* slender, 5.5 cm. long by 7 mm. thick at top and 4 mm. at bottom which is slightly enlarged, somewhat sulcate, slightly lacerate, darker than endoperidium. (This specimen has never been cut into hence the statement "white within and without, fibrillose-stuffed, becoming hollow," is a pure guess.) *Gleba* ferruginous. *Capillitium* hyaline to slightly tinted, threads not as well defined as in *Tylostoma*, flaccid, 3.5–5.6  $\mu$  thick, septa not seen. *Spores* globose, uniguttulate, 5.6–7.5  $\mu$  in diameter. *Epispore* fulvous, moderately but distinctly echinulate.

FIG. 1 Type of *Tylostoma gracile*FIGS. 2-4. Labels on box and with type of *T. gracile*

Miss White's figure of this species was undoubtedly made from the above described plant even to the slight remnant of the inner layer of the volva-cup shown at the base of her figure and the curves in the stem (FIG. 1). This plant used as the type of "*Tylostoma gracile*" is a small typical *Chlamydotus meyenianus* without its volva.

The first legend, figure 2, gives the original data on the collection but no name for the fungus; figure 3 is Wooton's label and shows the same plant as figure 2 but was given a name by Wooton when he sent it in May to the New York Botanical Garden; figure 4 shows the present label on the box top containing the specimen. the other 2 labels are inside the box. "Type of *T. gracile*" was inserted recently by the Garden authorities, not by Miss White.

No wonder Lloyd (1906) was unable to recognize "*Tylostoma gracile*," he evidently took at face value the type description and looked for it under the genus *Tylostoma*.

#### ACKNOWLEDGMENTS

I wish to make grateful acknowledgments to Dr. Fred J. Seaver for helpful suggestions and for the loan of valuable material and to John A. Stevenson for loan of material.

ALBUQUERQUE,  
NEW MEXICO

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## CONTRIBUTIONS TO THE MYCOFLORA OF BERMUDA—IV

F. J. SEAVER AND J. M. WATERSTON

(WITH 8 FIGURES)

The present paper is the fourth of a series (Seaver & Waterston 1940, 1941, 1942) based on determinations of fungi which have been collected in the Bermuda Islands during the last three decades. During the autumn of 1944, the junior author was granted leave of absence from Bermuda to work over material collected by the senior author together with H. H. Whetzel and Lawrence Ogilvie during January—February 1926, with a view to preparing a complete list of the local fungi. Much of this material had remained for many years unstudied at Cornell University.

The total number of named species of Schizomycetes, Myxomycetes, Phycomycetes, Ascomycetes, Ascolichenes, Basidiomycetes and Fungi Imperfecti recorded to date from Bermuda now amounts to over 750. These are distributed among 310 genera. Nearly 68.4 per cent of the total number of recorded species are contained in the following seven orders: Moniliales, 109; Agaricales, 84; Phyllostictales, 74; Sphaeriales, 68; Uredinales, 60; Lecanorales, 58 and Melanconiales, 30.

The general aspect of the mycoflora is sub-tropical or temperate North American, as one might expect in view of the Islands' geographical position. There is a noteworthy absence of orders which commonly predominate in strictly tropical regions and members of the Dothideales and Hemisphaeriales are poorly represented. The number of endemic species is small and is less than 7 per cent of the total number recorded.

About 64 per cent of the species are saprophytic and few are strictly terrestrial. Most of the saprophytic species occur on the debris of higher plants. The total number of species of fungi found associated with either living or dead parts of some of the commonest flowering plants is as follows: *Sabal bermudana*, 60; *Juniperus bermudiana*, 55; *Citharexylum spinosum*, 26; *Nerium*

*Oleander*, 20; *Musa Cavendishii*, 15; *Melia Azedarach*, and *Myrica cerifera*, 14; *Agave* sp., *Elacodendron Lancaum*, *Lycopersicon esculentum* and *Solanum tuberosum*, 12; *Coccolobis uvifera* and *Jasminum gracile*, 11; and *Rhizophora Mangle*, 10.

Although the total number of fungi recorded from Bermuda is quite satisfactory in view of the small area of the Islands, some 19 square miles, nevertheless the writers feel that a considerable amount of collecting work still remains to be done, particularly with regard to the soil inhabiting and aquatic species.

#### PHYCOMYCETES

##### DELACROIXIA CORONATA (Cost.) Sacc. & Sydow

This species was obtained in culture during an attempt to obtain spore shootings from apothecia of *Pseudopithyella minuscula* (Boud. & Torrend) Seaver, growing on decayed twigs of *Juniperus bermudiana* L., Agricultural Station, Paget East, Jan. 27, 1943, J. M. Waterston, det. D. H. Linder. It is of interest to note that White (1937: 148) has also reported this fungus on an operculate discomycete, *Peziza domiciliana* Cooke, at Ithaca, N. Y., as well as on other substrates.

The entomogenous nature of this species demonstrated by Kevorkian (1937: 194) was confirmed when dry-wood termites, *Kalotermes approximatus*, taken from Bermuda cedar, *Juniperus bermudiana* L., were exposed for two hours to petri dish cultures on 2 per cent dextrose potato agar and subsequently transferred to a moist chamber. Death took place in all specimens exposed to this treatment within eight hours. The fungus was only effective under conditions of high humidity and has not been found on dry-wood termites in the field in Bermuda. Martin (1942: 145) gives notes on the facultative parasitism of this species on insects and also deals with its synonymy.

##### ENTOMOPHTHORA VIRESCENS Thaxter

Parasitic on larvae of *Feltia subterranea* F., without definite station, December 1927, L. Ogilvie 34937 (CU). This is the species reported by Ogilvie (1928: 35) as being common on the dead bodies of cutworms found adhering to the leaves of plants

during the winter months. The discharged conidia form a flowing margin around the larvae, greenish-yellow in color in dried material. The ovate conidia measure  $35 \times 14 \mu$ . Previously known from Ontario, Canada, and Wooton, England.

*PILOBOLUS KLEINII* van Tiegh.

Discharged sporangia of this species caused disfigurement of the foliage of cauliflowers and cucumbers growing in a greenhouse, Paget East, Feb. 15, 1939, *H. S. Cunningham 34843, 34844 (CU)*. The same species was found under similar circumstances on leaves of *Chrysanthemum morifolium* Ram., in a greenhouse in Watervliet, New York, Oct. 22, 1932, *J. L. Young 20890 (CU)*.

ASCOMYCETES

*Bulgaria Thwaitesii* (Berk. & Br.) comb. nov. (FIG. 1)

*Rhizina Thwaitesii* Berk. & Br. Jour. Linn. Soc. (Bot.) 14: 102. 1875.

*Sarcosoma Thwaitesii* (Berk. & Br.) Petch, Annal. Roy. Bot. Gard. Peradeniya 4: 420. 1910.

This is not a Bermuda species but it has been reported in association with witches' brooms on Bermuda cedar, *Juniperus bermudiana* L., in Ceylon by Petch (1910: 421) and Boedijn (1932: 277) has suggested that it is this species that occurs on the same host in Bermuda. However one of us (Seaver 1928: 198, 1942: 320) has shown that the Bermuda species is referable to *Bulgaria melastoma* (Sow.) Seaver. Figure 1 (upper) shows this species on rotten bark of *Juniperus bermudiana* L., from roots of living trees exposed at soil level, Walsingham, Bermuda, Jan. 20, 1922, *H. H. Whetzel Bermuda Fungi No. 188*. This plant is characterized by apothecia which are frequently stipitate, with almost smooth, hyaline, ellipsoidal spores,  $20-25 \times 9-10 \mu$ .

In contrast, the Ceylon fungus, for which the new combination given above is proposed, is typically sessile, and has far larger spores,  $34-44 \times 15-20 \mu$ . These are covered with flattened warts. Figure 1 (lower) shows material of *Sarcosoma Thwaitesii* (Berk. & Br.) Petch, from branches of *Juniperus bermudiana* L., Peradeniya, Ceylon, Sept. 13, 1913, *T. Petch, Sydow Fungi*

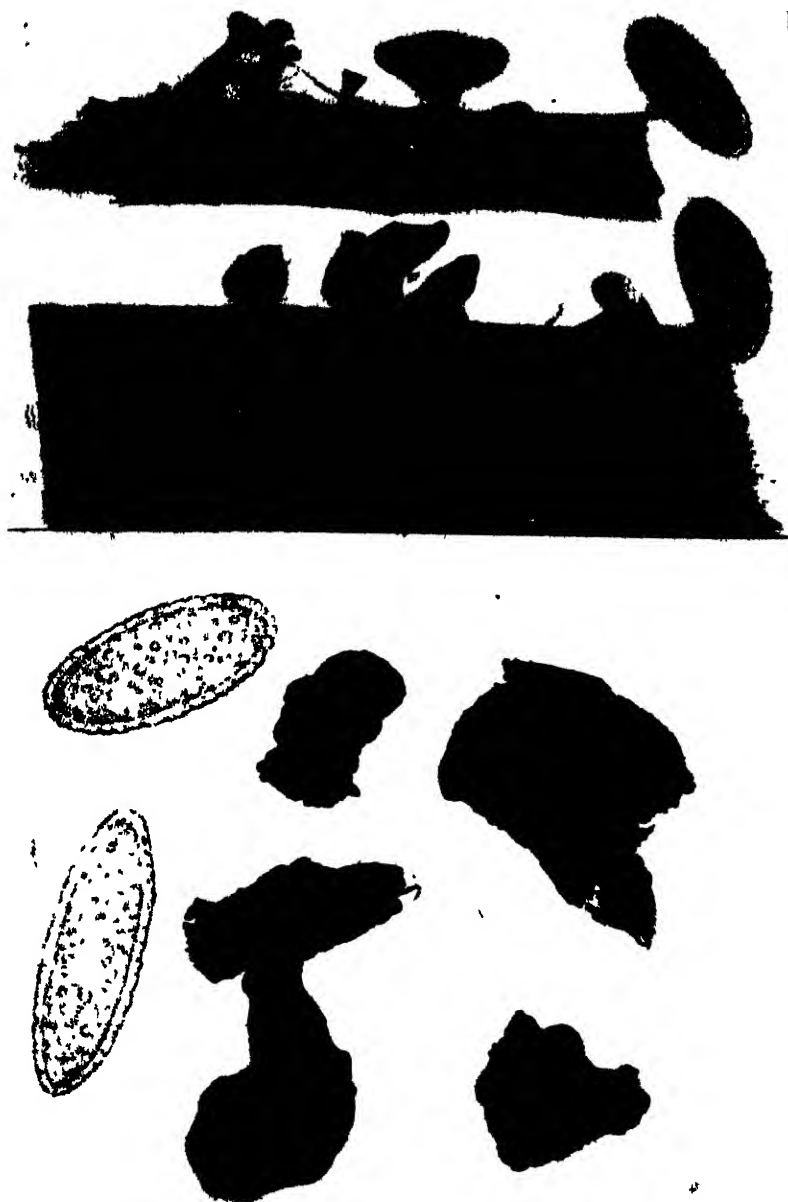


FIG. 1. (upper) *Bulgaria mclastoma* from Bermuda  $\times 1$ . (lower) *Bulgaria Thwaitesii* from Ceylon  $\times 2$ . Both specimens fruiting on *Juniperus bermudiana*. Both spores  $\times 1000$ .



*exotici* No. 424. This species does not appear to have been recorded in America. On the other hand, *B. melastoma* has a wide range in America. One interesting record of the latter, is a collection on *Juniperus barbadensis* L. (= *J. virginiana* L.), from Cinchona, Jamaica, B. W. I., Dec. 25-Jan. 8, 1908-09, *W. A. Merrill & Edna L. Merrill* 652 (NY). The material was taken in a wet mountainous region at 4,500-5,200 feet elevation. The ascospores averaged  $30\ \mu$  in length and were longer and more slender than the Bermuda material on *J. bermudiana*.

**Catabotrys deciduum** (Berk. & Br.) comb. nov. (FIG. 2)

*Hypoxylon deciduum* Berk. & Br. Jour. Linn. Soc. 14: 120. 1875.

*Bagnisiella palmarum* Pat. Bull. Soc. Myc. France 3: 176, 177. 1887.

*Catabotrys palmarum* (Pat.) Theiss. & Sydow, Ann. Myc. 13: 297, 298. 1915.

On fallen leaf bases of tall bananas, *Musa* sp., Devonshire, Feb. 3, 1926, *F. J. Scaver, H. H. Whetzel & L. Ogilvie* 34897 (CU); on dead petioles of *Sabal bermudana* Bailey, on the ground, Walsingham, Jan. 20, 1922, *H. H. Whetzel* 35004 (CU).

Previously known only from Central Provinces, India; Ceylon; Bintula, Borneo and New Caledonia. The Bermuda record is a noteworthy extension of range of this beautiful and interesting species. The writers are indebted to Dr. Julian H. Miller who examined the material on *Musa* and pronounced it identical with the type of *Hypoxylon deciduum* Berk. & Br., at Kew Herbarium.

The fungus is characterized by pulvinate stromata which rest on a subiculum and are entirely superficial (FIG. 2a). The perithecia have very long ostioles and are deeply imbedded in stromatic columns which become separated with age but remain united above. The spores are hyaline, ellipsoid and average  $6-7 \times 3\ \mu$  (FIG. 2b). Paraphyses are absent. Petch (1924: 163) lists this fungus in his Xylariaceae Zeylanicae among species *Dubiae et excludendae*, and gives the spore range for Ceylon material (No. 2881)  $6-9 \times 3\ \mu$ . He notes that Cooke (1883: 123) gave the spore range 15-18  $\times 3\ \mu$  and had passed it as *Hypoxylon*.

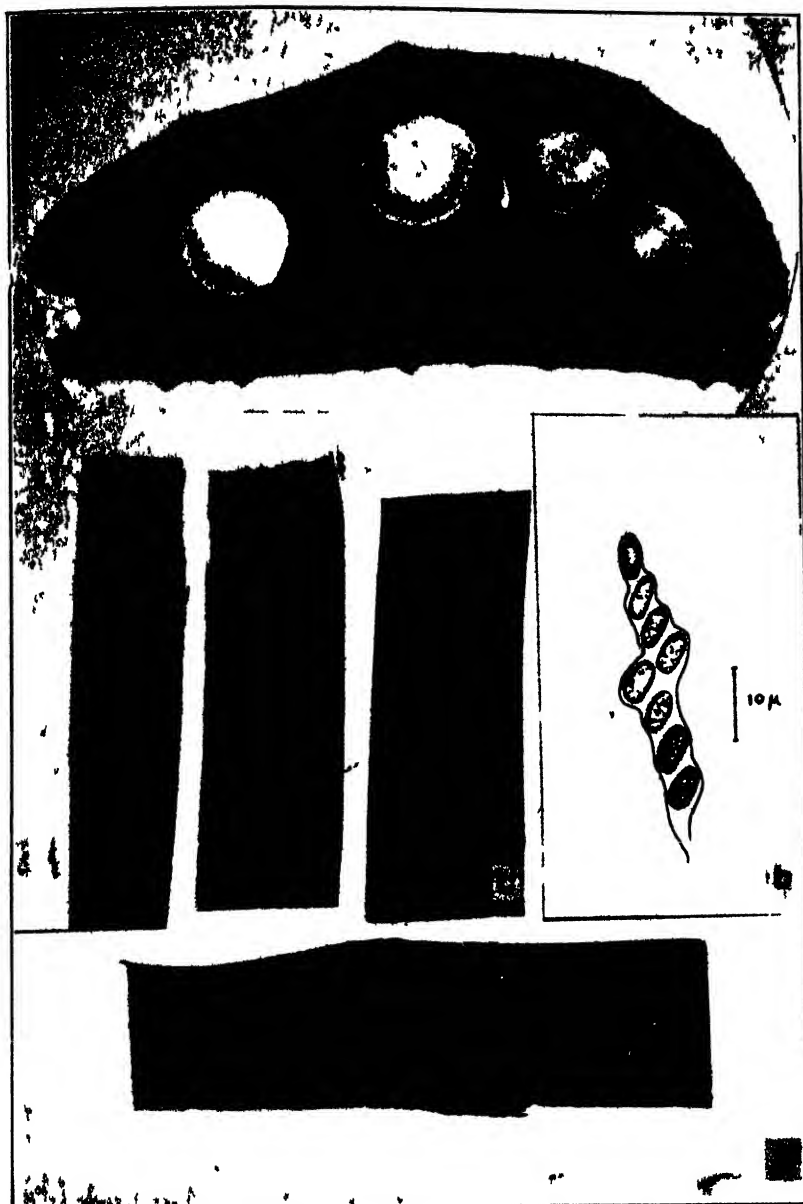


FIG. 2 (*Catabotrys deciduum*) (a) transverse section of stroma and subiculum removed from substrate (*Musa* sp), showing location of perithecia  $\times 50$ , (b) single ascus with spores, (c) stromata on fallen petiole of *Musa* sp  $\times 1$  (d) stromata on fallen petiole of *Sabal bermudana*  $\times 1$

The Bermuda specimens also agree very well with published descriptions of *Bagnisiella palmarum* Pat., which was placed in the Dothideales by Patouillard (1887: 176, 177) who gave the spore range  $6-7 \times 3-4 \mu$ . Theissen & Sydow (1915: 297, 298) later erected the genus *Catabotrys* Theiss. & Sydow for Patouillard's species and gave as their spore measurements  $6.5-7.5 \times 3 \mu$ . Their illustration showing a section of the stroma (*loc. cit.*, Pl. 2, fig. 5) compares well with our illustration (FIG. 2a). Petrak (1934: 339) emended the genus *Catabotrys* and transferred it to the Hypocreales where it would rightly appear to belong. The genus is represented by a single species for which the new combination given above is proposed.

The following Ascomycetes are new records: *Claviceps Paspali* Stevens & Hall, sphacelial stage on inflorescence of *Paspalum dilatatum* Poir., Pembroke, Oct. 12, 1921, E. A. McCallan 34908 (CU); *Daldinia vernicosa* (Schw.) Ces. & De Not., on dead trunk of *Morus rubra* L., scorched by fire, St. George's Island, Feb. 22, 1944, J. M. Waterston (GA), det. J. H. Miller; *Hypocrea lenta* (Tode) Berk. & Br., on bark of *Juniperus bermudiana* L., Agricultural Station, Paget East, Jan. 26, 1926, F. J. Seaver & H. H. Whetsel 34784 (CU); *Hypomyces candicans* Plowr., parasitic on sporangia and plasmodia of Myxomycetes during wet weather, Paget Marsh, November 1921, H. H. Whetsel 34784 (CU).

#### BASIDIOMYCETES

The following Basidiomycetes are new records: *Agaricus cinchonensis* Murrill, on soil, King Edward VII Hospital Grounds, Paget East, Dec. 12, 1938, F. J. Seaver & J. M. Waterston 191 (NY), det. A. H. Smith; *Cyphella cupulaeformis* Berk. & Rav., on bark of *Juniperus bermudiana* L., St. David's Island, May 22-June 6, 1914, S. Brown, N. L. Britton & P. Bisset 2081 (NY), common after rain and represented by eight additional collections; *Hygrophorus lactus* Fries, at base of *Sabal bermudana* Bailey, Paget Marsh, Dec. 3, 1912, S. Brown, N. L. Britton & F. J. Seaver 1312 (NY); *Iachnocladium semivestitum* Berk. & Curt., on leafmold under dense mat of *Jasminum gracile* Andrews, Walsingham, Jan. 20, 1922, H. H. Whetsel (CNC) and on soil,

near Trott's Pond, Feb. 5, 1926, *F. J. Seaver, H. H. Whetzel & L. Ogilvie B 41 (CNC)*, det. W. C. Coker as possibly the same as *Stereum proliferum* reported from Bermuda by Burt (1920: 116); *Lycoperdon epixylon* Berk. & Curt., on wood, Walsingham, Jan. 20, 1926, *F. J. Seaver, H. H. Whetzel & L. Ogilvie B 23 (CNC)*, det. W. C. Coker; *Pleurotus applicatus* (Batsch) Fries, on bark of *Juniperus bermudiana* L., following rain, Agricultural Station, Paget East, Oct. 16, 1940, *J. M. Waterston 299 (NY)*; *Ptychogaster cubensis* Pat., on *Myrica cerifera* L., growing from a knot-hole, Paget Marsh, Aug. 21, 1921, *H. H. Whetzel Bermuda Fungi No. 119*, det. R. Thaxter; *Scleroderma lycoperdoides* Schw., on soil among weeds, Agricultural Station, Paget East, Sept. 20, 1940, *J. M. Waterston 277 (NY)*, det. W. C. Coker; *Tulostoma pygmaeum* Lloyd, on soil, Grace's Island, Feb. 9, 1926, *F. J. Seaver & H. H. Whetzel 32623 (CU)*, det. W. C. Coker and reported previously only from Florida, Texas and Brazil.

## FUNGI IMPERFECTI

## CILIOSPORA GELATINOSA Zimm. (FIGS. 3, 4, 5)

On rotten petioles of *Archontophoenix Alexandrae* Wendel & Drude, Camden Marsh, opposite Rosebank, Paget East, associated with the stromata of *Helotium atosubiculatum* Seaver & Waterston, Nov. 31, 1941, *J. M. Waterston 31508 (CU)*, det. H. H. Whetzel (1942: 529); same station and substrate, Jan. 22, 1943, *J. M. Waterston 32617 (CU)*; on rotting foliage of *Juniperus bermudiana* L., Trimmingham's Hill, Paget East, held one month in moist chamber, Dec. 12, 1942, *J. M. Waterston 32614 (CU)*. Previously known only from Java on cacao pods. Petch (1943: 70) expresses doubt as to whether *Ciliospora* Zimm. is distinct from *Chaetospermum* Sacc. but we are assigning our specimens to the former genus until material of the latter can be obtained for study.

Spores from the *Archontophoenix* material measured  $26-35 \times 5-8 \mu$ , with a mean of  $28 \times 5 \mu$ , and those from *Juniperus* ranged from  $21-33 \times 5-8 \mu$  with a mean of  $26 \times 5 \mu$ . From this material, pure cultures were readily obtained by spore dilution on 2 per cent dextrose potato agar. Since it has grown and fruited readily in

artificial culture an opportunity was afforded to make a rather detailed study of a species of this peculiar and very interesting genus.

#### MORPHOLOGY

On its natural substrate, such as the fallen twigs of the juniper, the fruit bodies of *Ciliospora gelatinosa* appear as minute pearly-

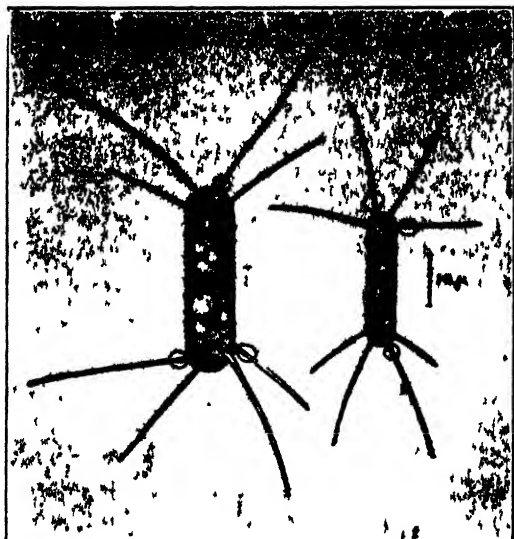


FIG. 3 Spore of *Ciliospora albida* from *Prunus serotina* (on left) compared with spore of *Ciliospora gelatinosa* from *Archontophoenix flex-andruc*.

white mucilaginous cushions, breaking forth through the ruptured epidermis of the leaves, usually a single fruit body from individual leaves, scattered here and there on the fallen branchlet. Removed on the tip of a needle, the base of the fruit body is seen to be deeply embedded in the leaf. It consists largely of a gelatinous mass of large appendaged, hyaline spores arising from a basal palisade of slender conidiophores embedded in a transparent, mucilaginous material. Enclosing this mass of spores and conidiophores is a very thin pinkish hyphal membrane of peculiar and characteristic pattern. This enclosing membrane is difficult to distinguish on fruit bodies from the juniper leaves but is quite obvious on fruit

bodies developed on agar. It is ruptured in irregular fissures as the spore-mass enlarges, appearing on mature fruit bodies as a pinkish collar about the basal portion. The conidia are cylindrical with rounded ends, slightly curved when observed lying on an uncurved side. Each conidium bears normally eight appendages arranged in two pairs near each end (FIG. 3). One pair is rather shorter and more slender and is attached somewhat farther from the end than the other pair. The members of each pair are attached to the spore opposite each other and alternate with those of the other pair. Each appendage usually bears a minute mucilaginous globule a short distance from its point of attachment. The appendages are rather broad at the base, tapering uniformly to a slender whip-like tip. The members of the two longer pairs are distinctly constricted for a short distance above the point of attachment. No such constriction has been observed in the members of the shorter pairs. The appendages are very transparent, shorter, and more difficult to see than are those of *Ciliostroma albidum*, but they are paired and attached to the body of the spore essentially as in that species. The longer appendages are about the length of the spore, 22–25  $\mu$ . The shorter ones are about 15–18  $\mu$  in length. Each spore is surrounded by a thin mucilaginous sheath. Basic fuchsin in aqueous solution stains the cytoplasm of the spore deep red and the appendages a faint pink. The mucilaginous envelope, however, is not readily stained.

Pycnidia and spores were readily produced on 2 per cent dextrose agar. Measurement of 200 spores produced in culture (No. 32617) gave a range of  $21\text{--}31 \times 4\text{--}7 \mu$ , with a mean of  $25.7 \times 5.2 \mu$ . These measurements conform closely with those given by Zimmerman (1902: 217) for his species *C. gelatinosa* ( $15\text{--}30 \times 5\text{--}6 \mu$ ). Whetzel (1942: 528) has shown that these measurements are definitely shorter than those recorded for *C. albidum* ( $28\text{--}40 \times 6\text{--}12 \mu$ , average  $35 \times 10 \mu$ ).

In order to clear up any possible confusion of the Bermuda species with *C. albidum*, fresh material of the latter was sought by the junior author at Lloyd Preserve, McLean, New York, at the same station where H. H. Whetzel and J. Niederhauser made the first collection in North America, Dec. 2, 1941 (Whetzel 1942: 525). Fallen leaves of *Prunus serotina* Ehrh., stromatized by *Rut-*

*stroemia Pruni-serotinae* Whetzel & White, were collected on November 4, 1944. These were placed in a moist chamber and thirty-six days later a few pycnidia were first seen on the upper surface of the leaves. Spore production was abundant, and no difficulty was experienced in getting the fungus in pure culture. A dried specimen of this collection made by the junior author is preserved in the Cornell University Plant Pathology Herbarium as No. 35003.

Both species of *Ciliospora* grew well on non-acidified 2 per cent dextrose potato agar. *C. albida* from the *Prunus* leaves made no growth at temperatures above 27° C. At 23° C. growth was submerged (FIG. 4, upper). The optimum rate of growth for this species was obtained at 21° C. and was accompanied by the production of a dense, white, cottony aerial mycelium, which turned a light buff color with age (FIG. 5, upper). Very few pycnidia were formed in plate cultures and then only after 4 weeks growth. Some tube cultures, twenty-one days old, produced a few pycnidia where the mycelium was in contact with the glass wall and at a temperature of 21° C. The spores produced compared favorably in size with field material.

*C. gelatinosa* from the *Archontophoenix* leaves was found to have a higher optimum temperature for growth around 27° C., as one would expect from a fungus found in a subtropical habitat. The Bermuda isolate grew readily on 2 per cent dextrose potato agar, with or without acidification with phthallic acid (pH 4.5) but refused, as did *C. albida*, to grow on this same medium acidified with lactic acid. Growth was rapid and very characteristic. The mycelium was almost entirely submerged but restricted to the upper millimeter or so of the media. The aerial hyphae were sparse, fibrillose appressed and never cottony as in *C. albida*. Growth was finely zonate, there being 30–40 narrow zones in a thallus covering an ordinary petri dish (FIG. 4, lower).

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FIG. 4. (upper) Plate culture of *Ciliospora albida* isolated from leaves of *Prunus serotina*, grown at 23° C., on 2 per cent dextrose potato agar, 14 days old, no zonation and pycnidia absent. (lower) Plate culture of *Ciliospora gelatinosa* isolated from petiole of *Archontophoenix Alexandrac*, grown at 23° C., on 2 per cent dextrose potato agar, showing abundant formation of pycnidia and spores when 14 days old. Note zonation.

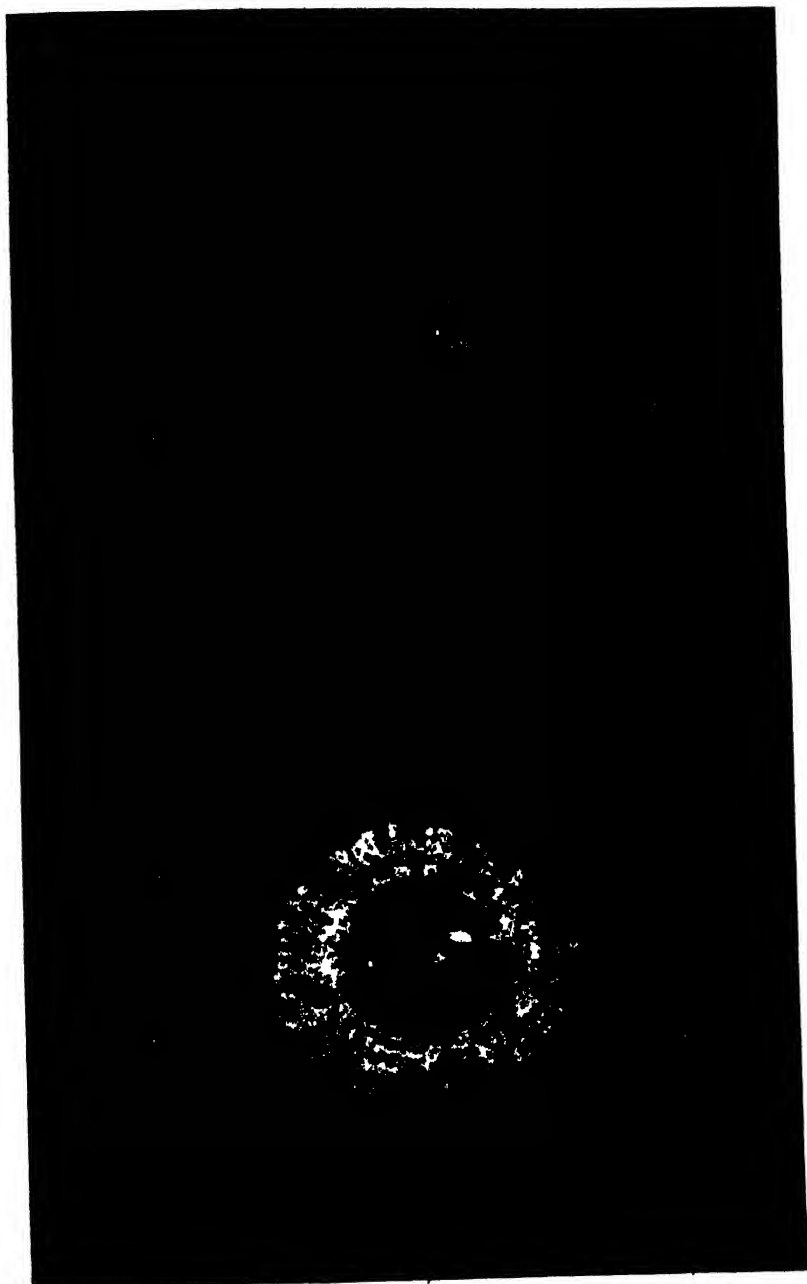


FIG. 4.



Fruit body initials appeared in less than a week, at first submerged, they eventually emerged as small (1–2 mm. diam.), hemispherical, cottony-white cushions, zonately arranged. The cottony hyphae finally collapse as the spore mass bursts the enveloping pinkish colored membrane. When the culture is ten to fourteen days old the fruit body appears as a pearly-white globule with a pinkish collar about its base. The pycnidia are often found aggregated in groups.

The fungus also fruited well on sterilized cellulose beer-glass coasters similar to those used by Tyler & Parker (1945: 258) for culturing *Ceratostomella Ulmi*. The pads were soaked in a potato extract solution before introducing the fungus inoculum (FIG. 5, lower). *C. albida* was grown on the same substrate but failed to produce pycnidia.

*C. gelatinosa* therefore appears to differ quite markedly from *C. albida* both in morphological and physiological characters. The readiness with which the former grows and fruits on dextrose potato agar makes it a desirable species for laboratory teaching. We shall be glad to distribute cultures of it on request as long as we have it available.

### **Macrophoma Lilii sp. nov. (FIG. 6)**

Pycnidia globosa, 160–210  $\mu$  in diametro, ostiolo distincto, rotundo, non-papillato, 20–35  $\mu$  in diametro, a superiore marginem nigrum exhibenti; sporophorae 12–15  $\times$  2–3  $\mu$ , crassae, simplices, in longitudine sporas paene aequantes; sporae 15–23  $\times$  3–7  $\mu$ , plerumque 18  $\times$  6  $\mu$ , hyalinae, non-septatae, fusiformes vel claviformes, extremis obtusis, rectae, plerumque eguttulatae.

Pycnidia globose, 160–210  $\mu$  diam., with distinct, round, non-papillate ostiole, 20–35  $\mu$  diam., showing a black rim when viewed from above; sporophores 12–15  $\times$  2–3  $\mu$ , stout, simple, almost as long as the spores; spores range from 15–23  $\times$  3–7  $\mu$ , average 18  $\times$  6  $\mu$ , hyaline, non-septate, fusiform to clavate, with blunt pointed ends, straight, mostly eguttulate.

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FIG. 5. (upper) Plate culture of *Ciliostpora albida* isolated from leaves of *Prunus serotina*, grown at 21° C., on 2 per cent dextrose potato agar, 14 days old. Note abundance of cottony aerial mycelium and absence of pycnidia. (lower) *Ciliostpora gelatinosa* isolated from petiole of *Archontophoenix Alexandrac*, grown at 27° C., on cellulose pad saturated with potato extract, 14 days old. Pycnidia and spores abundant.

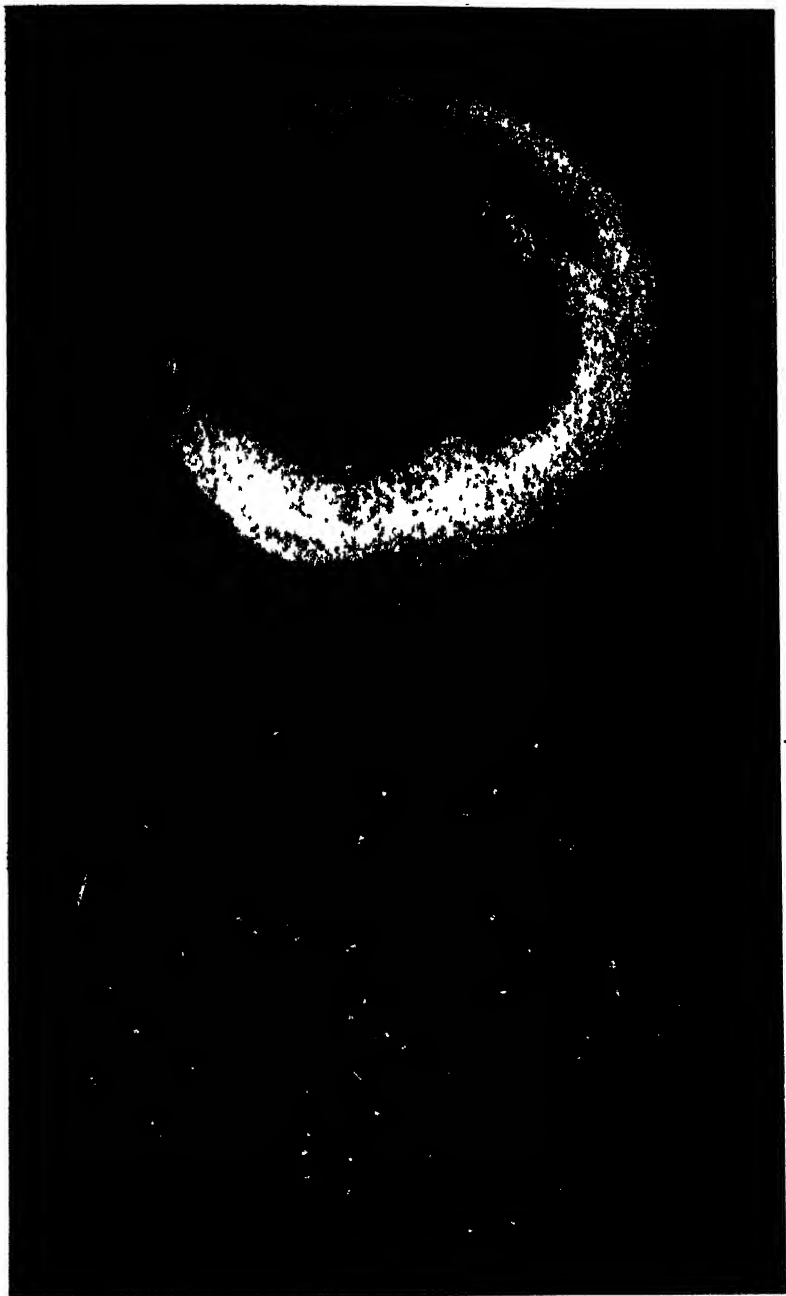


FIG. 5.

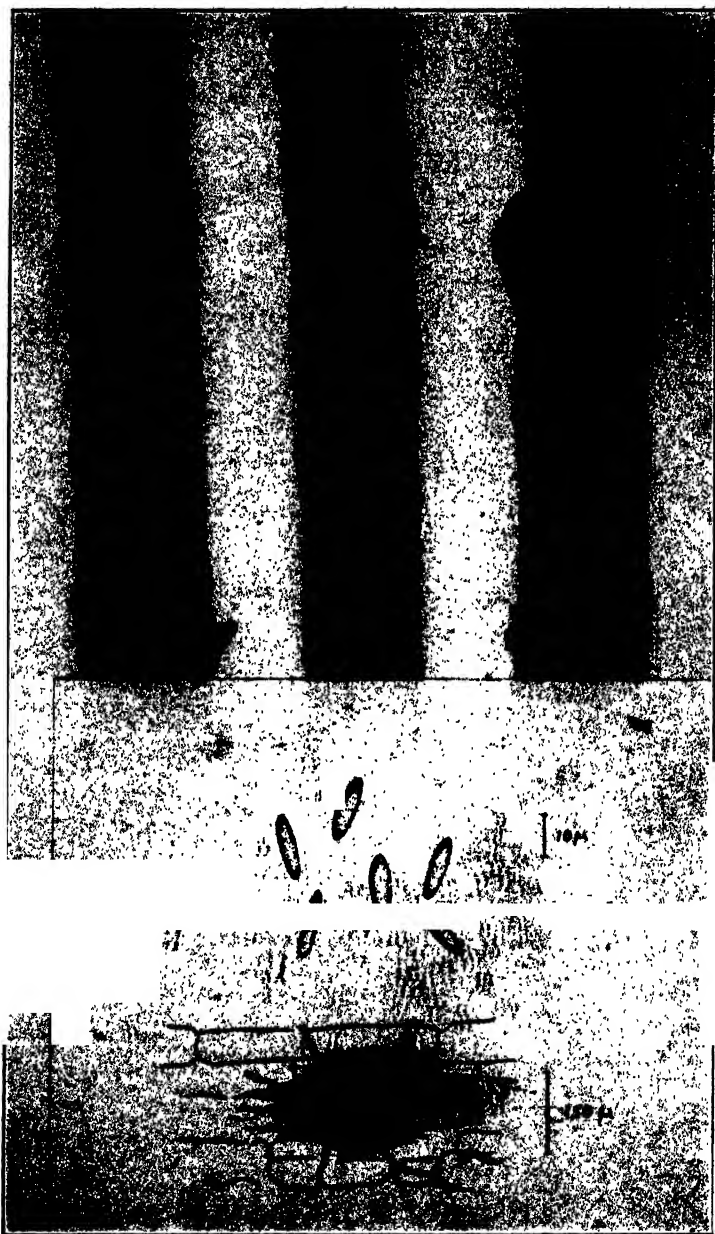


FIG. 6. Dead stems of *Lilium longiflorum* var. *eximium*, showing pycnidia of *Macrophoma Lilii*  $\times 2$ .

On dead stems of *Lilium longiflorum* var. *eximium* Baker, Agricultural Station, Paget East, June 1921, *H. H. Whetsel 35123* (CU), (type).

This species occurs commonly on dead stems of the Bermuda Easter lily during early summer after the plants have matured or have died back from some other cause. The flowering stalks are covered with the black pimple-like pycnidia and have the appearance of having been bleached almost white.

The fungus was isolated by Dr. G. R. Bisby from material collected by the junior author in 1938. The cultures were found to be slow in producing pycnidia and spores. The latter, when produced, ranged from  $15\text{--}20 \times 6\text{--}7 \mu$  and showed a close correlation in size with those produced on lily stems in the field. Although the spores are typically non-septate, Dr. Bisby found some which suggested that septa might eventually be formed.

No fungus has previously been described on lily in Europe or America which will fit this species. It is distinct from *Macrophoma Phaseoli* previously recorded from lily roots in Bermuda by Ogilvie (1928: 35).

### **Macrophoma Trichostomi** sp. nov. (FIG. 7)

Pycnidia globosa,  $150 \mu$  in diametro, ostiolo parvo, circulari,  $20 \mu$  in diametro, margine definito nigro; sporae modorum duorum, magnae  $18 \times 4 \mu$ , et parvae  $7 \times 2 \mu$ , hyalinae, cylindratae vel claviformes, plerumque rectae.

Pycnidia globose,  $150 \mu$  diam., with a small circular ostiole,  $20 \mu$  diam., surrounded by a definite black margin; spores distinctly of two sizes, large ones  $18 \times 4 \mu$ , and small ones,  $7 \times 2 \mu$ , hyaline, cylindrical or clavate, usually straight.

Parasitic on capsules of the endemic moss, *Trichostomum bermudianum* Mitt., Paget East, Feb. 10, 1922, *H. H. Whetsel 35119* (CU), (type).

This interesting little species has been collected only once in Bermuda, where it was found attacking a large percentage of moss capsules before they were fully developed. There are apparently no previous records of Phoma-like fungi on any North American moss and none has been reported heretofore on the genus *Trichostomum*. There are a group of *Phoma* spp. reported on moss capsules in Europe which have small spores ranging  $3\text{--}6 \times 1\text{--}2 \mu$ .

These are *Phoma muscorum* Rostrup (1903: 318), *Phoma Splachni* Rostrup (1904: 30), *Phoma muscicola* Smith (1910: 221) and *Phoma Orthotrichi* Smith & Ramsbottom (1914: 326). According to Grove (1935: 121) the latter is a young stage of *P. muscicola*. None of these species appears to produce the large spores characteristic of the Bermuda species.

*Phyllosticta Casaresi* Gonzalez (1916: 369) on moss leaves, has spores  $14-22 \mu \times 3.5-5 \mu$  and most closely approaches the Bermuda species. It is, however, a foliicolous species and is not recorded on capsules. There is no mention either, in the original description, of the presence of microspores. The writers have accordingly felt justified in erecting a new species for the Bermuda fungus.

### **Schizotrichum Conocarpi** sp. nov. (FIG. 8)

Sporodochia gregaria, cylindrata vel subglobosa, superficialia, nigra, 75-150  $\mu$  in diametro, 200-250  $\mu$  alta, setis similiter coloratis, projicientibus, parietibus crassis, simplicibus, septatis, ad septa haud constrictis, ad extrema acutis, concoloratis,  $200-600 \times 7 \mu$ ; conidiophorae obsoletae; conidia hyalina, filiformia, recta vel curva, 6-8-septata, ad septa haud constricta, guttulate, in longitudine variabilia pro numero septorum, ea 6-septata  $57 \times 3 \mu$ , ea 7-septata  $60-72 \times 3 \mu$ , ea 8-septata  $75-84 \times 3 \mu$ .

Sporodochia gregarious, cylindrical to sub-globose, superficial, black, 75-150  $\mu$  diam., 200-250  $\mu$  high, with similarly colored, projecting, thick-walled setae, simple, septate, not constricted at septa, pointed at tips, concolorous,  $200-600 \times 7 \mu$ ; conidiophores obsolete, conidia hyaline, filiform, straight or curved, 6-8 septate, not constricted at septa, guttulate, variable in length according to the number of septa, those 6-septate are  $57 \times 3 \mu$ , those 7-septate range from  $60-72 \times 3 \mu$ , those 8-septate range from  $75-84 \times 3 \mu$ .

On fallen, decaying leaves of *Conocarpus erecta* L., Walsingham, Jan. 22, 1926, *L. Ogilvie* 35120 (CU), type; at same station and on same substrate, Jan. 19, 1943, *J. M. Waterston* 35121 (CU).

The genus *Schizotrichum* was erected by McAlpine (1903: 562) for the monotypic species *S. Lobeliae* McAlpine, with setae  $70-95 \times 4.5-5 \mu$  and spores 3-6 septate and ranging 28-35 (with some  $50-60 \mu$ )  $\times 1-2 \mu$ . The Bermuda fungus differs from the Australian species in possessing far longer setae and spores. The

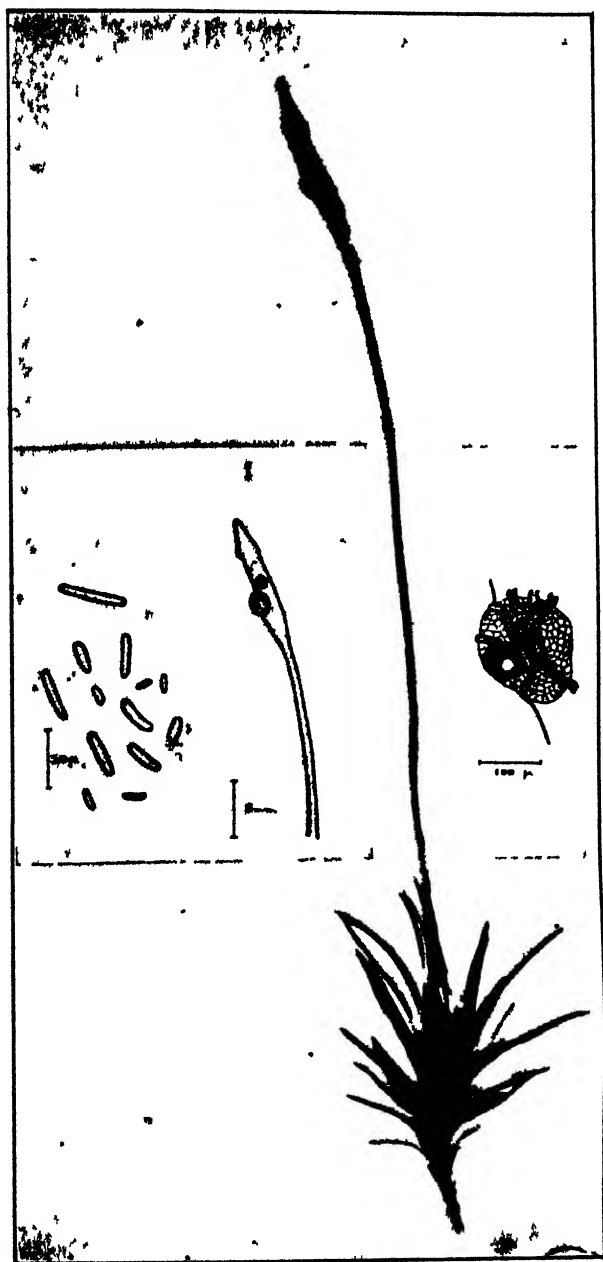


FIG. 7. Single plant of *Trichostomum bermudianum*, showing immature capsule parasitized by *Macrophoma Trichostomi*  $\times 2$

hyphae connecting the sporodochia do not appear to be as prominent as in McAlpine's species.

The second collection by the junior author, although taken at the same station as the type, was made without knowledge of Ogilvie's collection, which was discovered in the Herbarium at



FIG. 8. *Schizotrichum Conocarpi*: (upper) natural habit  $\times 15$ ;  
(lower) sporodochium and spore.

Cornell University. This would indicate that the species is well established in Bermuda.

Interesting species of Fungi Imperfecti hitherto unrecorded from Bermuda are as follows: *Brencklea Sisyrinchii* (Ell. & Ev.) Petrak, on leaves of *Sisyrinchium bermudianum* L., Paget, March

1922, H. H. Whetzel 34973 (CU), previously known from Berkeley, California, Washington County, N. Y., and North Dakota; *Colletotrichum Lili* Plakidas, on dead stems of *Lilium longiflorum* var. *eximium* Baker, Agricultural Station, Paget East, June 15, 1921, H. H. Whetzel 34959 (CU); *Exosporium Leucaenae* Stevens and Dalbey, on leaves of *Leucaena glauca* (L.) Benth., Walsingham, Jan. 21, 1926, H. H. Whetzel & L. Ogilvie Bermuda Fungi No. 200, previously known only from Puerto Rico; *Myrothecium roridum* Tode ex Fries, on weathered shell of fruit of *Crescentia Cujete* L., Smith's Parish, Dec. 9, 1938, F. J. Seaver & J. M. Waterston 173 L (NY), known only as a saprophyte in Bermuda; *Myrothecium verrucaria* (Alb. & Schw.) Ditmar ex Fries, on weathered cardboard, Shelly Bay, Mar. 30, 1939, J. M. Waterston 251 (NY); *Pestalotia adusta* Ell. & Ev., on leaves of loquat, *Eriobotrya japonica* Lindl., Devonshire, October 1927, L. Ogilvie 35229 (CU), det. E. F. Guba; *Pestalotia longi-aristata* Maubl., on fruit of loquat, *Eriobotrya japonica* Lindl., Agricultural Station, Paget East, February 1922, H. H. Whetzel 35228 (CU), det. E. F. Guba; *Pestalotia vermiformis* Massee, associated with die-back of stems of *Barringtonia speciosa* Forst., Agricultural Station, Paget East, June 7, 1929, H. S. Cunningham, det. E. F. Guba; *Phlcospora Dodonaeae* Nattrass, on leaves of *Dodonaea jamaicensis* DC., St. David's Island, Dec. 16, 1940, J. M. Waterston 428 (NY), 35036 (CU), previously known only from Cyprus; *Phoma polygramma* Sacc., on dead peduncles of *Plantago lanceolata* L., South shore, Devonshire, March 1922, H. H. Whetzel 34970 (CU); *Phomopsis Malvacearum* (West.) Grove, on stem of *Hibiscus Sabdariffa* L., Agricultural Station, Paget East, J. M. Waterston 35016 (CU), spores  $6-8 \times 1 \mu$ , "b" spores,  $18-21 \times 1 \mu$ ; *Spiegassinia ornata* Sacc., on old leaves of crab-grass, *Stenotaphrum secundatum* (Walt.) Kuntze, opposite Paynter's Vale, Walsingham, Jan. 21, 1926, H. H. Whetzel 35010 (CU); *Sphaerosporium lignatile* Schw., on rotten wood in slat-house, Agricultural Station, Paget East, Dec. 11, 1940, J. M. Waterston 35220 (CU), det. D. H. Linder; *Sporendonema epizoum* (Corda) Ciferri & Redaelli, on stale gingerbread, Pembroke, June 14, 1943, J. M. Waterston, det. E. W. Mason; *Stachybotrys subsimplex* Cooke, on fallen leaves of *Musa* sp., Hungry Bay, Dec. 2, 1938,



*F. J. Seaver & J. M. Waterston 80b* (NY), det. E. W. Mason; *Stephanoma tetracocum* van Zinderen—Bakker, parasitic on *Geoglossum nigrum* Cooke, Harrington Sound, Dec. 7, 1912, S. Brown, N. L. Britton & F. J. Seaver 1564 (NY); *Trichothecium Helminthosporii* (Thüm.) Sacc., parasitic on *Helminthosporium Ravenelii* Berk. & Curt., on *Sporobolus Berteroanus* (Trin.) Hitch. & Chase, Paget Marsh, Sept. 25, 1921, *H. H. Whetsel Bermuda Fungi No. 177*; *Ustilaginoidea Dichromenae* P. Henn., in ovaries of *Dichromena colorata* (L.) Hitch., Paget Marsh, Aug. 12, 1921, *O. Degener Bermuda Fungi No. 27*, det. H. M. Fitzpatrick.

## ACKNOWLEDGMENTS

The writers are indebted to Mrs. M. W. Allen of the Botany Department, Cornell University, for assistance in the preparation of the Latin diagnoses and to Mr. R. W. Fisher, Photographic technician of the same Institution, for help in the preparation of the illustrations. Appreciation is also expressed to the various authorities listed in the text who have aided in the determination of species.

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PAGET EAST, BERMUDA

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## NEW SPECIES OF PORIA<sup>1</sup>

L. O. OVERHOLTS AND J. L. LOWE

(WITH 2 FIGURES)

In the course of independent studies of miscellaneous collections of fungi of the genus *Poria* (Family *Polyporaceae*) and the timber decays produced by them, the authors have found apparently undescribed species, which are here proposed as new. One of these was segregated but never published by another author; two are independently proposed; and four are jointly proposed by the two authors as they were duplicated in our individual collections. The junior author is responsible for the Latin descriptions, except for that of *Poria carbonica*, which was prepared by Dr. Robert E. Dengler, Professor of Classical Languages, The Pennsylvania State College.

Color names within quotation marks are from R. Ridgway, *Color Standards and Color Nomenclature*, Washington, D. C., 1912.

### *Poria alutacea* Lowe, n. sp. (FIG. 1, B)

Annua, effusa ad 5 cm., membranacea-coriacea, facile separabilis, nec odore nec gustatu distincta; margine alba, byssina et implicita, vel lata vel angusta, rhizomorphae plerumque adsunt; superficie pororum alba vel pallida et crenea, leviter nitida; tubulis ad 0.5 mm. longis, in statu sicco subericis; poris rotundis vel angulatis, 5-6 singulis plerumque in uno mm., dissaeptimentis demum modice tenuibus, acie integra vel fimbriata; clavus hyphatis nullis; cystidiculis maiorem partem immersis, obtusis, diametro 4-5  $\mu$ ; basidiis late clavatis, 8-10  $\times$  4-5  $\mu$ ; sporis hyalinis, levibus, cylindratis, rectis vel leviter curvatis et tunc late allantoides, 2.5-3.5  $\times$  1.5  $\mu$ ; subiculo albo, ad 0.1 mm. crasso, firmo, ex hyphis coniuncte intertextis, rare ramosis, maiorem partem solidis, diametro 1.5-2  $\mu$ ; saeptis autem nullis, et, cum premuntur, non facile separabilibus; hyphis tramarum similibus.—In ligno coniferarum et deciduarum, specimen typicum prope Tully, N. Y. collectum a J. L. Lowe (n. 2701), et in herbario Farlowiano in Universitate Harvardiana conser-

<sup>1</sup> Authorized for publication on October 29, 1945, as Paper No. 1295 in the Journal Series of the Pennsylvania Agricultural Experiment Station. Contribution No. 151, Department of Botany, The Pennsylvania State College, State College, Pa., and from the Department of Forest Botany and Pathology, New York State College of Forestry, Syracuse, New York.

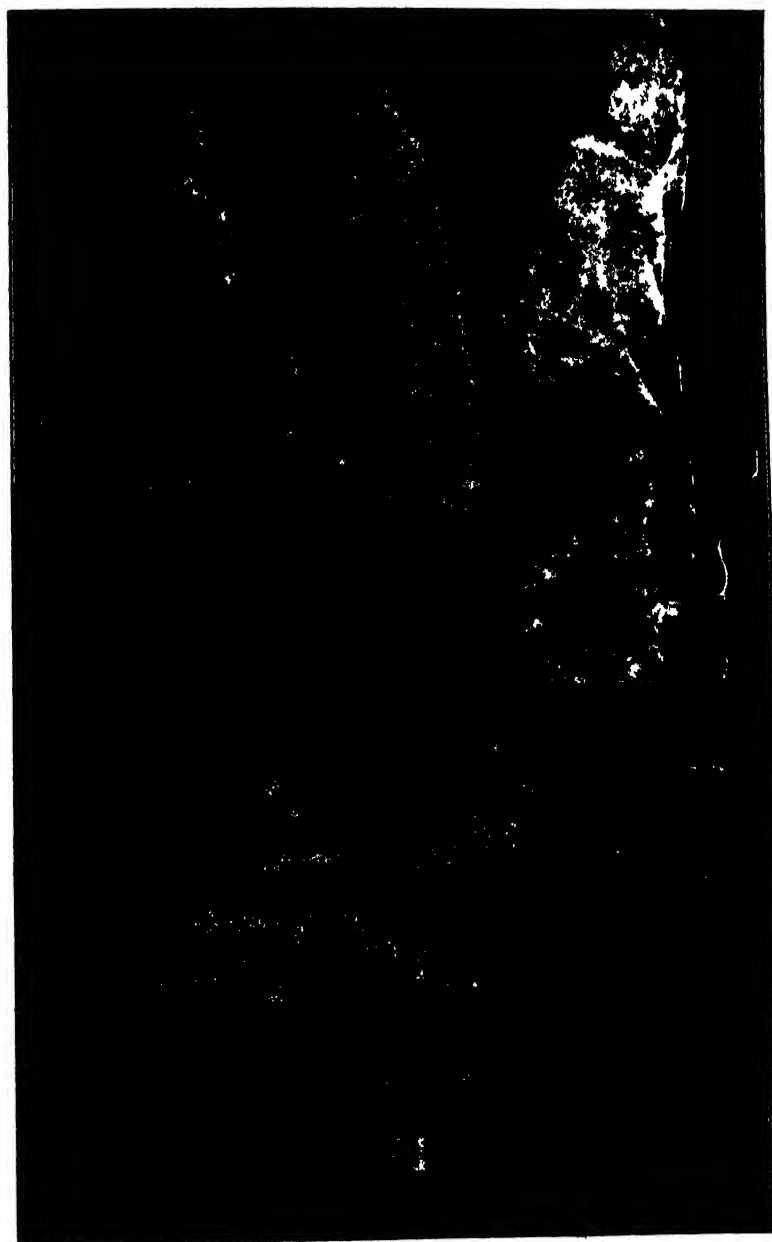


FIG. 1. A, *Poria lenta*  $\times 1$  (Catskill Mts., Peck); B, *Poria ulstacca*  $\times 1$  (type, Lowe 2701); C, *Poria carbonica*  $\times 2$  (type, Overholts 22021).

vandum. Id exemplum consimile est *Poriae fimbriatellae* (Peck) Sacc., sed cystidiis nullis, poris et hyphis subiculi minoribus et sporis cylindricis nec ellipsoideis.

Annual, effused up to 5 cm., membranous-tough, readily separable, without distinct taste or odor; margin white, matted-myceloid, wide or narrow, usually with well-developed rhizomorphs; pore surface white to pale cream, slightly glancing; tubes up to 0.5 mm. long, corky when dry; pores rounded or angular, averaging five to six per mm., the dissepiments becoming moderately thin, entire to fimbriate; hymenium without hyphal pegs so far as seen; cystidioles mostly immersed, bluntly pointed, 4–5  $\mu$  diameter; basidia broadly clavate, 8–10  $\times$  4–5  $\mu$ ; spores hyaline, smooth, short-cylindric, straight, or slightly curved and then appearing somewhat broad-allantoid, 2.5–3.5  $\times$  1.5  $\mu$ ; subiculum white, about 0.1 mm. thick, firm, the hyphae closely interwoven, sometimes incrustated, rarely branched, mostly solid, 1.5–2  $\mu$  diameter, without cross walls, difficultly separable under pressure; tramal hyphae similar.

On the wood of coniferous and deciduous trees; Tully, N. Y., Lowe 2701 (type); also Lowe 2643 and 2702; known also in New York from Saratoga Lake (H. D. House), and from Warrensburg, Lowe 1826, 2361; from Lake Timagami, Ontario (R. F. Cain), and by sporophores sterile but otherwise agreeing, from Pennsylvania, Lowe 2761, and North Carolina (F. O. Grover). The plant is similar to *Poria fimbriatella* (Peck) Sacc. but lacks large cystidia, the pores are slightly smaller, the subiculum hyphae more slender, and the spores are not ellipsoid.

***Poria carbonica* Overholts, n. sp. (FIG. 1, C)**

\* Effusa ad aliquot centimetra, annualis, vel si rediviva per secundum annum tubulis saltem non lamipatis, 3–12 mm. crassa, margine tenui vel interdum subumescens, superficie in substratis verticalibus plus minusve nodulosa, tenax et cascata, valde dura ut siccatur, alba vel senescens isabellina; tubulis 2–10 mm. longis, longioribus obliquis, oribus 3–4 per mm., muris aliquantum crassis et integris, interdum tenuibus hiantibusque; subiculo bene formato, albo, firmo, nullo modo fibroso, 0.5–3 mm. crasso; sporis anguste ellipsoideis vel paene breviter cylindricis, levibus, hyalinis, 3.5–6  $\times$  2–3  $\mu$ ; basidiis clavatis, 10–12  $\times$  4.5–6  $\mu$ ; hyphis subiculi valde congelatis (vel saltem non tinctis, saepe lumine solum viso), 3–4  $\mu$  diam., aliquantum ramosis, quibusdamque saeptis et fibulis instructis; hyphis tramae 2–2.5  $\mu$  diam. et distinctioribus.

Hab. In ligno mortuo et saepe ambusto arborum coniferarum. Specimen typicum in stipite conifero Aug. 31, 1938, Saanichton, Brit. Columbiae, a Dr. Irene Mounce et Jean Straight repertum est et in herbario Overholtsii (n. 22021) conservandum.

Effused for several centimeters, annual or if reviving for more than one season at least the tubes not in layers, 3–12 mm. thick, the margin thinning out or at times a bit tumid, on vertical substrata the surface more or less nodulose with the tubes vertical, cheesy-tough when fresh, drying quite hard, white or in age isabelline; tubes 2–10 mm. long, the latter lengths where oblique, the mouths three to four per mm., the walls rather thick and entire, at times becoming thin and gaping; subiculum well developed, white, firm, not at all fibrous, 0.5–3 mm. thick; spores narrow-ellipsoid or almost short-cylindric, smooth, hyaline,  $3.5-6 \times 2-3 \mu$ ; basidia clavate,  $10-12 \times 4.5-6 \mu$ ; subiculum hyphae with walls considerably gelatinized (or at least unstaining and often only the lumen visible),  $3-4 \mu$  diameter, somewhat branched, with some cross walls and clamps, those of trama  $2-2.5 \mu$  diameter and more distinct.

On dead and often charred wood of coniferous trees. Type collected on coniferous log at Saanichton, British Columbia, August 31, 1938, by Dr. Irene Mounce and Jean Straight (Overholts Herb. 22021). The following additional collections are in Overholts Herbarium; on end of burned log of *Pseudotsuga taxifolia* (Poir.) Brit., Cook Creek, Vancouver Isl., August 18, 1938, I. Mounce (84444); on *Picea Engelmanni* (Parry) Engelm., Upper Priest River, Idaho, August 1, 1924, C. R. Stillinger (1838); on *Pinus ponderosa* Dougl., Missoula, Mont., Sept., 1916, J. R. Weir (4169); on *Pseudotsuga taxifolia*, Carson, Wash., October 29, 1935, G. H. Englerth (58033); on *Pseudotsuga taxifolia*, Siuslaw National Forest, Oregon, Sept. 23, 1938, Englerth and Childs (94012); under side of drift log, Kaloma, Wash., Oct. 12, 1909, C. J. Humphrey (5905); on *Tsuga heterophylla* (Raf.) Sarg., Revelstoke, B. C., Aug. 26, 1930, J. R. Hansbrough (40652); on *Pseudotsuga taxifolia* boat timber, Seattle, Wash., May 15, 1942, G. H. Englerth (94160) comm. R. W. Davidson; on *Pseudotsuga taxifolia*, Vancouver Isl., British Columbia, Aug. 6, 1942, J. E. Bier (V-1640); *ibid.*, Sept. 2, 1942 (V-162); Coyote Creek, Lane Co., Ore., Oct. 22, 1939, Maxwell Doty.

This is *Poria* no. 36 in W. B. Cooke's paper,<sup>2</sup> as evidenced by specimens sent by Dr. Maxwell Doty. Cooke cites 12 additional collections, all from Oregon, and all on *Pseudotsuga*. The associated rot is usually of the brown carbonizing type.

<sup>2</sup> Amer. Midland Nat. 27: 692. 1942.

***Poria bombycina* (Fries) Cooke. (FIG. 2, E)**

After this manuscript was submitted the collections cited below were found to agree with *Polyporus hians* Karst., No. 619 in Fungi Fenniae Exsic., a synonym of *P. bombycina* according to Bresadola and Pilát. No other American collections are known to the authors. As a description in English has not been found, one is included here.

Annual, effused up to 5 cm., readily or difficultly separable, without odor; margin white, sometimes changing to tawny on drying, fibrous or mycelioid, narrow to wide; pore surface grayish-white or pale yellowish-orange to pale pinkish-brown, becoming pale pinkish-brown on drying; tubes up to 1 mm. long, soft, soft-fragile when dry; pores circular to elongated and somewhat sinuous, averaging two to three per mm., the dissepiments remaining rather thick, entire; hymenium distinct from the trama, without cystidia; basidia broadly clavate, with clamp connections at the base,  $15-22 \times 5-8 \mu$ ; spores ellipsoid or oblong-ellipsoid, smooth, hyaline or with a faint yellow tinge,  $6-7.5 \times 3.5-4 \mu$ ; subiculum tawny when dry, fine-fibrous, up to 0.2 mm. thick, the hyphae loosely interwoven, thin-walled,  $2-4 \mu$  diameter, rarely to moderately branched, with frequent clamps, also with cross walls, continuous without change into the trama, readily separable by pressure; tramal hyphae similar.

On the wood of coniferous trees, Warrensburg, N. Y., Lowe 2225 and 2504, North Elba, Peck; N. Hamp., Farlow; and from Gull Lake, Timagami Nat. Forest, Ontario, Canada, S. M. Pady (Overholts Herb. 17072 and Herb. Univ. Toronto 4037). The plant resembles *Poria Vaillantii* (Fries) Cooke but is not rhizomorphic and changes color on drying.

***Poria fissiliformis* Pilát in litt., n. sp.**

Annua, effusa ad 30 cm. vel ultra, plerumque coriacea, in statu sicco dura et fragilis, plerumque facile separabilis, nec odore nec gustatu distincta; margine alba vel lutea, radiata-fimbriata vel implicita, latiore et conspicua; superficie pororum vel crenea vel lutea, sed in sicco eadem est vel obscurans ad helvam colorem; tubulis ad 6 mm. longis, in statu sicco vitreis et fragilibus, poris 5-8 singulatis plerumque in uno mm., angulatis, acie tenui, integra vel fimbriata; cystidiis frequentibus vel raris, conicis, partim immersis ad  $7 \mu$  diametro, cystidicula aliquando adsunt; basidiis clavatis,  $8-11 \times 4-4.5 \mu$ ; sporis hyalinis, levibus, oblongis vel ellipsoideis,  $2.5-5 \times 1.5-2.5 \mu$ ; subiculo albo vel

pallido et cremeo, ad 0.2 mm. crasso, in statu sicco verum fibrato et fragili, ex hyphis laxae vel coniuncte intertextis, crasse tunicatis, modice ramosis, non saeptatis, nec non hyphis tenuiter tunicatis et fibulatis, diametro 3–5  $\mu$ , et cum premuntur, non facile separabilibus; hyphis tramarum tenuiter tunicatis, non-saeptatis, diametro 2–2.5  $\mu$ .—In ligno deciduarum, specimen typicum in *Acer* prope Creve Coeur Lake, Missouri, a L. O. Overholts collectum, et in herbario Overholtsii (n. 19780) conservandum. Id exemplum consimile est *Poriae subacidae* (Peck) Sacc., sed sporis et poris minoribus.

Annual, effused up to 30 cm. or more, leathery or sometimes crisp when fresh, drying hard and brittle, usually readily separable, without distinct odor or taste; margin white to buff, radiate-fimbriate or matted, rather wide and conspicuous; pore surface cream to pale yellow-orange, drying pale cream to light orange, or "apricot buff," glancing, the tubes up to 6 mm. long, glassy-fragile when dry, the pores averaging five to eight per mm., angular, the dissepiments thin, edges entire to fimbriate; hyphal pegs rarely present; cystidia obscure, frequent to rare, conic, partially immersed, up to 7  $\mu$  diameter; cystidioles sometimes present; basidia clavate, 8–11  $\times$  4–4.5  $\mu$ ; spores hyaline, smooth, short-oblong to ellipsoid, 2.5–5  $\times$  1.5–2.5  $\mu$ ; subiculum white to pale cream, up to 0.2 mm. thick, fibrous-fragile when dry, the hyphae loosely or compactly interwoven, a mixture of thick-walled, moderately branched, aseptate hyphae and of thin-walled hyphae with clamps, 3–5  $\mu$  diameter, difficultly separable with pressure; trama continuous with the subiculum, the hyphae rather thin-walled, without septa, 2–2.5  $\mu$  diameter, at juncture of tubes with a variable amount of thick-walled, rarely branched aseptate hyphae, 2.5–5  $\mu$ .

On the wood of deciduous trees; type collected on *Acer* at Creve Coeur Lake, Missouri, by L. O. Overholts, and deposited in the Overholts Herbarium (n. 19780); known also in New York from Newcomb, Lowe 2351, from Tully, Lowe 2679, 2716, 2726, 2746, and from Warrensburg, Lowe 2247, 2351, Carlberg 39 and 53; from Vermont (P. Spaulding), and from Manitoba (G. R. Bisby). The plant has the aspect of *Poria subacida* (Peck) Sacc. but has smaller spores and pores.

***Poria illudens* Overholts and Lowe, n. sp. (FIG. 2, D)**

Annua, effusa ad 8 cm., coriacea, in statu sicco suberica, vel facile vel difficile separabilis, nec gustatu nec odore distincta; margine angusta et fimbriata, concolore superficie pororum, quae est crenea vel leviter lutea, in statu sicco similis vel leviter obscurans, sordida vel nitida; tubulis ad 4 mm.



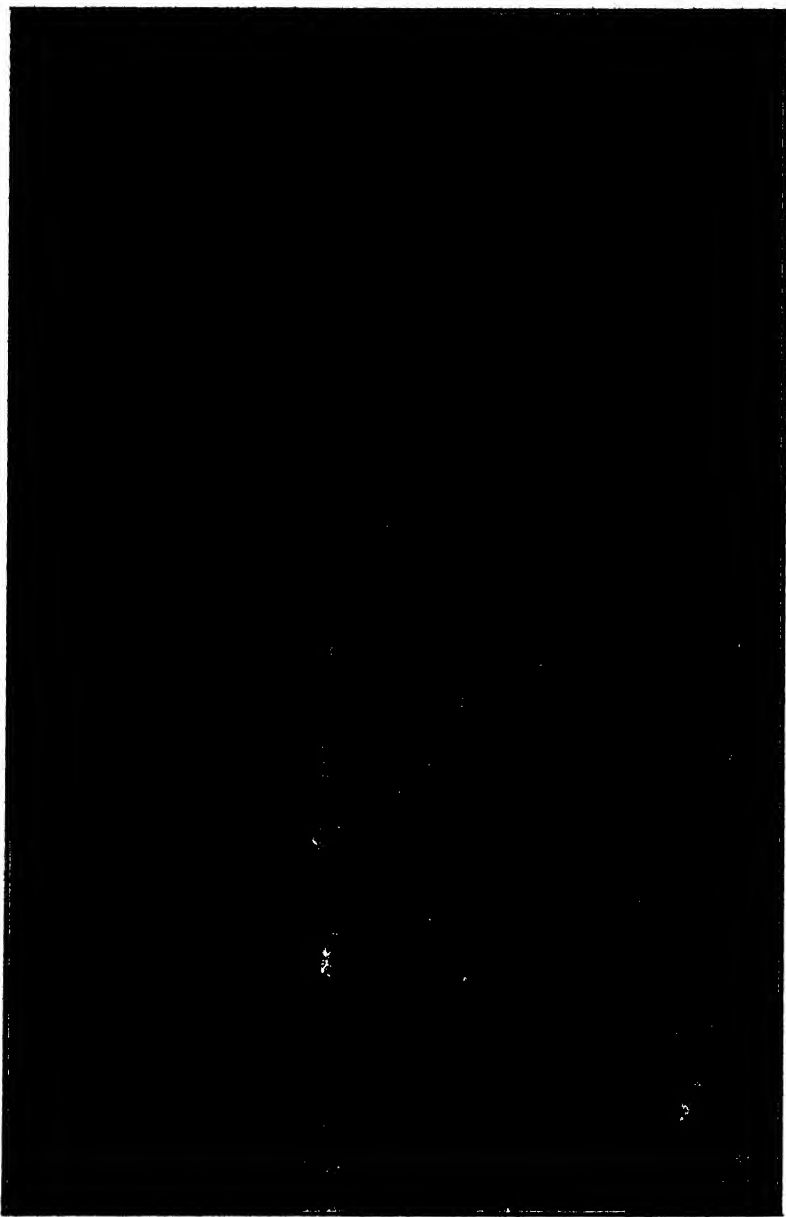


FIG. 2. D, *Poria illudens*  $\times 2$  (Lowe 2428); E, *Poria bombycina*  $\times 2$  (S. M. Pady); F, *Poria rubens*  $\times 1$  (Lowe 2392).

longis; poris rotundis vel demum daedaloideis vel sinuosis, quacumque superficies est inclinata, 3-4 singulis plerumque in uno mm., dissaepimentis demum tenuioribus, acie integra; clavis hyphatis modo numerosis modo absentibus; cystidiis raris et in hymenio immersis, tenuiter tunicatis, diametro 5-9  $\mu$ , forma haud dissimilis pedis; basidiis late clavatis, 10-15  $\times$  4-6  $\mu$ ; sporis hyalinis, levibus, late ovatis vel globosis, 2-4  $\times$  2-3  $\mu$ ; subiculo albo, in statu sicco parvatum fibrato et lentiore, ad 0.2 mm. crasso, ex hyphis laxae vel compactius intertextis, maiorem partem solidis, diametro 2-3  $\mu$ , saeptis nullis, rare ramosis, etiam cum hyphis non nullis tenuiter tunicatis et intricate ramosis, diametro 2-4  $\mu$ , fibulis minutis et obscuris, et cum premuntur, facile separabilibus; hyphis tramarum similibus, sed pallidis et luteis in hydrate kalico, arte contextis, et saeptis nullis.—In ligno coniferarum et aliquando deciduarum, specimen typicum prope Brandon, Vermont, a H. G. Eno collectum, et in herbario L. O. Overholtsii (n. 1913) conservandum. Id exemplum consimile est *Poriac versiporae* (Pers.) Rom., sed sporis minoribus et hyphis praecipuis non fibulatis.

Annual, effused up to 8 cm., leathery and moist when fresh, tough-corky when dry, readily or difficultly separable, without distinct odor or taste; margin narrow, finlbrate, concolorous with the pore surface; tubes up to 4 mm. long, their mouths cream to buff or somewhat yellowish, sometimes darkening somewhat on drying, dull or glistening, subangular, or becoming daedaloid or sinuous on inclined surfaces, averaging 3 to 4 per mm., the edges becoming thin, entire; hyphal pegs sometimes abundant, sometimes absent; cystidia seen only in the thinnest sections, rare, imbedded in the hymenium, thin-walled, 5-9  $\mu$  diameter, shaped like the foot of a stocking; basidia broadly clavate, 10-15  $\times$  5-6  $\mu$ ; spores hyaline, smooth, broadly oval to globose, 2-4  $\times$  2-3  $\mu$ ; subiculum white, fine-fibrous and rather soft when dry, up to 0.2 mm. thick, the hyphae loosely to rather compactly interwoven, mostly solid, 2-3  $\mu$  diameter, without cross walls, rarely branched, mixed with a small amount of thin-walled, sometimes intricately branched hyphae 2-4  $\mu$  diameter, with very inconspicuous clamps, separating readily by pressure; tramal hyphae pale yellowish in KOH, closely interwoven, thin-walled to solid, rarely branched, without cross walls, 2-3  $\mu$  diameter, separating readily on pressure.

On the wood of coniferous or less often of deciduous trees; type specimen collected on *Tsuga canadensis* (L.) Carr. at Brandon, Vt., by H. G. Eno and deposited in the Overholts Herbarium (n. 1913); known also from Warrensburg, N. Y., Lowe 2083, 2085, 2428, 2452, and Carlberg 48. The plant is very similar to *Poria versipora* (Pers.) Rom., but with smaller spores and without clamps on the predominant subiculum hyphae.

***Poria lenta* Overholts and Lowe, n. sp. (FIG. 1, A)**

Annua, effusa ad 8 cm., mollis et valida, vel facile vel difficile separabilis, nec gustatu nec odore distincta; margine alba et byssina, vel angusta vel latiore; superficie pororum alba, in statu sicco crenea, leviter nitida; tubulis ad 2.5 mm. longis; poris rotundis vel aliquantum angulatis vel sinuosis quaecumque superficies est inclinata, 2-4 in uno mm.; dissaepimentis demum tenuioribus, acie integra; clavis hyphatis nullis, nullisque cystidiis; basidiis cylindratis vel late pyriformibus,  $15-19 \times 6-8 \mu$ ; sporis hyalinis, levibus, plerumque guttulatis, latis ovoideis vel subglobosis,  $5-6 \times 4-5 \mu$ ; subiculo albo, ad 0.1 mm. crasso, aliquando usque in substratum rhizomorpheis, mollibus et fibratis, ex hyphis rare ramosis, crasse tunicatis, diametro 2-4  $\mu$ , saeptis nullis, et, cum premuntur, non facile separabilibus, trama continuo; hyphis tramarum similibus sed diametro 1.5-2.5  $\mu$ .—In ligno coniferarum, specimen typicum in ligno *Tsugae canadensis* (L.) Carr. prope Warrensburg, New York a J. L. Lowe collectum (n. 1767) et in herbario L. O. Overholtsii (n. 24093) conservandum. Id exemplum consimile est *Poriae molluscae* (Pers.) Bres., sed sporis maioribus et hyphis non saeptatis.

Annual, effused up to 8 cm., soft and tough, easily or difficultly separable, without distinct taste or odor; margin white, mycelioid, narrow to rather wide; pore surface white, cream when dry, slightly glancing; tubes up to 2.5 mm. long, pores circular to somewhat angular or sinuous on inclined surfaces, averaging 2 to 4 per mm., the dissepiments becoming rather thin, the edge entire; hymenium without hyphal pegs; cystidia sometimes represented by broadly fusoid blunt organs 6-8  $\mu$  diameter; basidia cylindric to broadly pyriform,  $15-19 \times 6-8 \mu$ ; spores hyaline, smooth, usually with a large globule, broadly oval to subglobose,  $5-6 \times 4-5 \mu$ ; subiculum white, up to 0.1 mm. thick, sometimes with rhizomorphic strands extending into the substratum, soft and fibrous, the hyphae rarely branched, thick-walled, 2-4  $\mu$  diameter, without septa, difficultly separable by pressure; trama continuous with the subiculum, of similar hyphae but only 1.5-2.5  $\mu$  diameter.

On the wood of coniferous trees; type collected on *Tsuga canadensis* (L.) Carr. at Warrensburg, N. Y., Lowe 1767, and deposited in the Overholts Herbarium (n. 24093); known also from Warrensburg, Lowe 2450 and 2555, and from the Catskill Mts., N. Y. (C. H. Peck). The plant is similar to *Poria mollusca* (Pers.) Bres. but with larger spores and with non-septate hyphae.

***Poria mappa* Overholts and Lowe, n. sp.**

Annua, interrupte effusa ad 10 cm. vel ultra, adnata, odore non distincta; margine alba, arachnoidea, vel angusta vel lata; superficie pororum alba, in statu sicco pallida et crenea vel sordida et lutea, haud nitida; tubulis bene

formatis saepe, priusquam nascitur hymenium, cerosis, in statu sicco fragilibus, ad 1 mm. longis, poris demum angulatis, 3 fere singulatis in uno mm., vel 2-4, dissaepimentis demum tenuibus, acie autem integra; hymenio ex trama distincto; cystidiis non visis; basidiis clavatis,  $12-15 \times 5-7 \mu$ ; sporis hyalinis, levibus, cylindricis, vel rectis vel leviter curvatis vel aliquando paene subfusiformibus,  $7-12 \times 2.5-3 \mu$ ; subiculo albo, ad 0.2 mm. crasso, in statu sicco molli, ex hyphis plerumque compacte intertextis, diametro  $2.5-3.5 \mu$ , tenuiter tunicatis vel solidis, modice ramosis, fibulatis et, cum premuntur, facile separabilibus; hyphis tramarum similibus, sed diametro  $2-2.5 \mu$ .—In ligno coniferarum, specimen typicum prope Enderby, British Columbia, a D. C. Buckman collectum et in herbario L. O. Overholtsii (n. 24445) conservandum. Id exemplum consimile est *Poria reticulatae* (Pers. ex Fries) Cooke, sed poris maioribus et hyphis fibulatis.

Annual, interruptedly effused up to 10 cm. or more, adnate, without distinct taste or odor; margin white, arachnoid, narrow to wide; pore surface white, when dry pale cream or sordid yellowish, dull; tubes often becoming, well-formed before being lined with the hymenium, soft and easily mashed when fresh, fragile when dry, up to 1 mm. long, the pores becoming angular, averaging three per mm. (two to four per mm.), the dissepiments becoming thin, edge entire; hymenium distinct from the subhymenial tissue; cystidia none; basidia clavate,  $12-15 \times 5-7 \mu$ ; spores hyaline, smooth, cylindric and straight to slightly curved or occasionally almost subfusiform,  $7-12 \times 2.5-3 \mu$ ; subiculum white, up to 0.2 mm. thick, soft when dry, the hyphae for the most part compactly arranged,  $2.5-3.5 \mu$  diameter, thin-walled to solid, moderately branched, with abundant clamps, readily separable under pressure; tramal hyphae similar but  $2-2.5 \mu$  diameter.

On the wood of coniferous trees; type collected at Enderby, British Columbia, Oct. 14, 1944, by D. C. Buckman (Overholts Herb. n. 24445) on *Thuja plicata* D. Donn. Known also from Newcomb, N. Y., Lowe 2312. The sporophore is somewhat similar to that of *Poria reticulata* (Pers. ex Fr.) Cooke but with larger pores and with clamped hyphae. The rot produced seems to be of the brown cubical type.

### ***Poria rubens* Overholts and Lowe, n. sp. (FIG. 2, F)**

Annua, effusa ad 15 cm., cerosa, in statu sicco dura et fragilis, facile separabilis, nec gustatu nec odore distincta; margine angustiore, minuta strigosa vel implicita vel radiata-fibrata, et vel concolore vel albida; superficie pororum aurea, "Salmon-orange," et in aetate et in statu sicco remisse purpurea, "Russet-vinaceous"; tubulis ad 8 mm. longis, hydrate kalico breviter purpurascens; poris plus vel minus rotundis, 3 singulis plerumque in uno

mm., dissaepimentis demum tenuibus, acie integra vel alba-fimbriata; hymenio a trama distinctiore; cystidiis nullis; basidiis anguste clavatis,  $13-19 \times 5-6 \mu$ ; sporis hyalinis, levibus, oblongis vel ita brevibus, ut oblongae-ellipsoideae videantur,  $3.5-5 \times 2-2.5 \mu$ ; subiculo ex colore dissaepimentorum paene ad colorem sordide album mutante, ad 0.5 mm. crasso, cum parvis sub microscopico granulis, ex hyphis rare ramosis, vel crasse vel tenuiter tunicatis, rare fibulatoriis, diametro 3-4 (6)  $\mu$ , et, cum premuntur, facile separabilibus; hyphis subiculi neque dissimiles sunt hyphae tramae.—In ligno coniferarum, specimen typicum prope Owl Creek, British Columbia, a J. R. Hansbrough collectum (n. 40660) et in herbario L. O. Overholtsii (n. 13984) conservandum.

Annual, effused up to 15 cm., soft and waxy when fresh, hard and brittle when dry, readily separable, taste and odor not distinctive; margin rather narrow, minutely strigose or matted or radiately fibrous, concolorous or paler to whitish; surface of the pores orange, "Salmon orange," in older portions and on drying dull purplish, or "Russet-vinaceous"; tubes up to 8 mm. long, briefly lavender in KOH; pores more or less regularly angular, averaging 3 per mm., the dissepiments becoming thin, edge entire or sometimes white-fimbriate; hymenium rather distinct from the tramal tissue; cystidia none; basidia narrowly clavate,  $13-19 \times 5-6 \mu$ ; spores hyaline, smooth, oblong or so short as to appear oblong-ellipsoid,  $3.5-5 \times 2-2.5 \mu$ ; subiculum shading from dissepiment color to nearly white next the substratum, up to 0.5 mm. thick, with much fine granular matter in microscopic section, the hyphae rarely branched, thick- or thin-walled, with rare clamps, 3-4 (6)  $\mu$  diameter, readily separated by pressure; tramal tissue similar.

On the wood of coniferous trees; type collected at Owl Creek, British Columbia, by J. R. Hansbrough (n. 40660), June 15, 1930, and deposited in Overholts Herbarium as n. 13984; known also from New Hampshire (D. H. Linder, Herb. Farlow), from New York, Lowe 2392, from Michigan (D. V. Baxter), and from Lake Timagami, Ontario (S. M. Pady).

*Poria carnicolor* Baxter appears to be very similar except for its larger spores,  $5.5-7 \times 2-3 \mu$ .

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# THE ACTION OF SULFONAMIDES ON CERTAIN FUNGI PATHOGENIC TO MAN<sup>1</sup>

FREDERICK T. WOLF<sup>2</sup>

The widespread use of sulfonamides in the treatment of infections of bacterial origin has suggested the possibility of using these compounds in the treatment of mycotic infections. There is probably no fungus infection against which one or more of the sulfa drugs has not been tried.

The results of administration of sulfonamides by the oral route have been more successful in cases of actinomycosis than with other mycotic infections. A considerable number of cases of this disease have been rapidly and completely cured following sulfonamide therapy (Walker 1938; Miller and Fell 1939; Dorling and Eckhoff 1940; Ogilvie 1940; Dobson, Holman and Cutting 1941; Mitchell 1942; Bénbow, Smith and Grimson 1944). Reports of cures following the oral administration of sulfonamides in a few cases of Madura foot (Dixon 1941), torulosis (Reeves, Butt and Hammack 1941; Marshall and Teed 1942), blastomycosis (Schroeder 1940), moniliasis (Van Bree 1941), sporotrichosis (Navarro-Martin 1940), epidermophytosis (Pfalzgraf 1941) and various bronchopulmonary mycoses (de Almieda and Lacaz 1942) have been recorded. Attempts to cure histoplasmosis (Moore and Jorstad 1943) and primary pulmonary coccidioidomycosis (Goldstein and McDonald 1944) by sulfonamides have failed. In consideration of these clinical studies, it should be pointed out that the number of cases is small, the basis of treatment has been largely empirical, and too often sulfonamide treatment has been instituted in advanced cases only when more accepted means of therapy have failed.

The rational use of sulfonamides in the therapy of mycotic in-

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fections must in general depend upon evaluation of the action of these compounds upon cultures of fungi *in vitro*. The fungistatic action of the sulfonamides was discovered by Fourneau, Tréfouël, Tréfouël, Nitti and Bovet (1936), who noted that the growth of *Aspergillus niger* was greatly delayed by the addition of sulfanilamide to the culture medium. Cutting and Gebhardt (1941), while studying the effect of sulfanilamide, sulfathiazole, and sulfadiazine upon *Actinomyces hominis*, found that sulfanilamide in a concentration of 50 or 100 mg. per cent checked the growth of this organism completely. Both sulfathiazole and sulfadiazine, however, were more effective than sulfanilamide in similar concentrations.

Lewis and Hopper (1941) studied the action of sulfanilamide, sodium sulfapyridine, sulfathiazole, sodium sulfathiazole, sulfadiazine and sodium sulfadiazine upon *Trichophyton gypseum* and *Monilia albicans*. They summarize their results as follows: "None of the compounds tested had any demonstrable effect on the growth of *Monilia albicans*. With *Trichophyton gypseum*, however, on examination after two weeks, some limitation of growth was seen to have been caused by all the compounds and complete retardation of growth had been accomplished by means of sulfanilamide in a dilution of one per cent. After three weeks, minute colonies began to appear."

These results were confirmed and extended by the work of Dimond and Thompson (1942) upon *Trichophyton gypseum* and *T. purpureum*. Experiments in which spores were suspended in solutions of various sulfonamides for various periods, and subsequently washed and inoculated upon an agar medium, indicated no significant signs of injury as a result of this treatment, since the cultures grew normally after the removal of the drug. The action of sulfanilamide was thus clearly shown to be fungistatic rather than fungicidal in nature. Further experiments demonstrated that sulfanilamide was far more effective than sulfapyridine, sulfathiazole, sulfaguanidine, or sodium sulfadiazine in inhibiting growth of these fungi, and measurements of growth rates showed that the fungistatic effect was amenable to interpretation as an extension of the lag phase of the growth curve. The fungistatic effect of sulfanilamide was much more pronounced on a peptone-free me-

dium, indicating that peptone presumably contains anti-sulfonamide factors.

Noojin and Callaway (1943) have reported upon the action of seven different sulfonamides on cultures of *Blastomyces dermatitidis*. Sulfadiazine and sulfanilamide were the most effective compounds tested. The concentrations required for fungistasis, however, were well above the limit which can be maintained in the blood and tolerated by the patient, so that the most effective clinical use of the sulfonamides in cases of blastomycosis must be restricted to local application. These investigators (Noojin and Callaway 1944) have also determined the action of nine sulfonamides upon cultures of *Sporotrichum schenckii*. Sulfanilamide and sodium sulfapyridine were the most effective, but again, as in the case of *Blastomyces dermatitidis*, high concentrations of the compounds were required to inhibit growth completely.

Senturia and Wolf (1945) studied the action of sulfonamides applied to cultures of fungi isolated from cases of otomycosis. The growth of *Aspergillus fumigatus*, *A. niger*, *A. glaucus*, *A. Sydowi* and *Mucor corymbifer* upon plates of Sabouraud's agar is markedly inhibited by sulfanilamide, but not by sulfathiazole, sulfadiazine, sulfaguanidine, or sulfamerazine, when the quantity of the drug approximates 20-30 mg. per culture. *Monilia albicans*, however, is unaffected by any of these sulfonamides, confirming the findings of Lewis and Hopper (1941).

As a result of these studies upon the fungi of otomycosis, further work concerning the effect of sulfonamides upon several other fungi of clinical importance was done. The present report is concerned with the findings of these studies.

#### MATERIALS AND METHODS

The fungi studied were as follows: *Candida* (*Monilia*) *albicans*, *C. krusei*, *C. tropicalis*, *C. parakrusei*, *C. pseudotropicalis*, *Cryptococcus neoformans*, *Epidermophyton floccosum*, *Trichophyton mentagrophytes* (*T. gypsum*), *T. rubrum*, *Microsporum gypsum*, *M. canis*, *Hormodendrum pedrosoi*, *H. compactum*, *Phialophora verrucosa*, *Sporotrichum schenckii* and *Monosporium apiospermum*. All cultures were obtained through the courtesy of Dr.



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The fungi were grown on Sabouraud's agar in an incubator maintained at 37° C. The sulfonamides tested were sulfanilamide, sulfathiazole, sulfadiazine and sulfaguanidine. The drugs were applied in a manner similar to that previously employed with fungi isolated from cases of otomycosis (Senturia and Wolf 1945).

For each of the sixteen organisms, one plate was inoculated to serve as a control. Other plates, inoculated at the same time, were immediately dusted with the powdered sulfonamide, the amount applied approximating 20 mg. per plate. Because of the possibility of variation in the results, each experiment was done several times.

The time allowed for incubation of the cultures prior to evaluation of the drug varied with the organism being tested. In the case of *Cryptococcus* and the various species of *Candida*, yeast-like organisms which grow very rapidly, a period of 3-5 days was sufficient. The remaining mycelial organisms grow more slowly, so that a period of two weeks was allowed.

#### RESULTS

Examination of the plates at the end of the stated periods of incubation disclosed great differences in the action of the various drugs upon the growth of a particular organism, and also differences in the growth responses of different fungi to a single sulfonamide. In general it appeared that the sulfonamides, in the dosage applied, either allowed the fungi to grow at a rate approximating that of the controls, or else inhibited their growth practically completely. It was therefore possible to segregate the fungi into those susceptible and those non-susceptible to the action of a particular sulfonamide.

Sulfanilamide was the only one of the sulfonamides tested which showed appreciable fungistatic activity. Some of the plates to which sulfanilamide was applied showed no macroscopically visible growth whatever at the end of a two week period. It was found that sulfanilamide is very markedly fungistatic to *Trichophyton mentagrophytes*, *T. rubrum*, *Epidermophyton floccosum*, *Microsporum canis*, *M. gypseum* and *Sporotrichum schenckii*. Sulfa-

nilamide has no definite fungistatic action, however, upon *Candida albicans*, *C. krusei*, *C. tropicalis*, *C. parakrusei*, *C. pseudotropicalis*, *Cryptococcus neoformans*, *Monosporium apiospermum*, *Hormodendrum pedrosoi*, *H. compactum* or *Phialophora verrucosa*.

Sulfathiazole, sulfadiazine and sulfaguanidine are not appreciably fungistatic toward any of the organisms tested. No growth-inhibitory effect, or at most a very slight one, was obtained with any of these compounds. If the assumption be granted that *in vitro* tests provide a valid means of determining the effectiveness of chemotherapeutic agents for clinical use, the results indicate that sulfonamide treatment of moniliasis, torulosis, chromoblastomycosis and the type of maduromycosis due to *Monosporium apiospermum* would be unsuccessful.

#### APPENDIX

Since the completion of the experiments mentioned above, a report by Keeney, Ajello and Lankford (1944) concerned with the action of sodium sulfathiazole, sodium sulfadiazine and sodium sulfamerazine upon pathogenic fungi has come to our attention. In addition to the organisms with which we were concerned, Keeney *et al.* have also studied *Microsporium audouini*, *M. felineum*, *Blastomyces dermatitidis*, *Coccidioides immitis*, *Histoplasma capsulatum* and *Actinomyces hominis*.

These investigators have employed a technique which eliminates the effect of anti-sulfonamide factors in the nutrient media. In our own study, not employing such refinements of technique, we have nevertheless been able to demonstrate that at least one sulfonamide, namely sulfanilamide, is fungistatic in spite of the presence of known anti-sulfonamide factors in the medium. If sulfonamides are to be of value clinically, they must overcome the anti-sulfonamide factors present in tissue fluids.

Keeney *et al.* have shown that the sodium salts of the sulfonamides may be fungicidal to *Microsporium audouini*, *Phialophora* (*Hormodendrum*) *pedrosoi* and *Histoplasma capsulatum* if a sufficiently high concentration is employed. These workers conclude that the results obtained with the sodium salts of the sulfonamides are not sufficiently impressive to warrant clinical trial, except for sodium sulfamerazine in the case of chromoblastomycosis and so-

dium sulfathiazole in treatment of histoplasmosis. It is to be hoped that further *in vitro* studies, and clinical trials of substances found to be superior under these conditions, may eventually result in better methods of therapy of mycotic diseases.

#### SUMMARY

Sulfanilamide is very fungistatic to *Trichophyton mentagrophytes*, *T. rubrum*, *Epidermophyton floccosum*, *Microsporum canis*, *M. gypseum* and *Sporotrichum schenckii*, *in vitro*.

Sulfanilamide has no definite fungistatic action *in vitro* upon *Candida albicans*, *C. krusei*, *C. tropicalis*, *C. parakrusei*, *C. pseudotropicalis*, *Cryptococcus neoformans*, *Monosporium apiospermum*, *Hormodendrum pedrosoi*, *H. compactum* and *Phialophora verrucosa*.

Sulfathiazole, sulfadiazine and sulfaguanidine are not appreciably fungistatic toward any of these organisms under *in vitro* conditions.

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# AN UNDESCRIBED SPECIES OF *ELSINOË* FROM MYSORE

M. T. THIRUMALACHAR

(WITH 7 FIGURES)

The genus *Elsinoë* Raciborski includes several well known parasites causing the scab or anthracnose disease of economic plants. The genus was founded by Raciborski (1900) to accommodate the fungus on *Conavalia gladiata* collected in Java. As a preliminary step in the course of a detailed monographic account of the genus *Elsinoë*, Jenkins and Bitancourt (1941) have given revised descriptions of the diagnostic characters of the genus and its conidial stage *Sphaceloma* de Bary, according to which the genera *Isotexis* Sydow and *Plectodiscella* Woronichin are treated as synonyms of *Elsinoë*.

In India the conidial stage of the sour-orange scab, *Sphaceloma Fawcetti* Jenkins, was collected as early as 1867 in Bengal though this was not discovered until 1933 when Jenkins and Fawcett (1933) examined herbarium material of *Citrus medica* deposited at the Arnold Arboretum. Kar and Saha (1943) recently described the remedial measures for controlling the scab of pumelo (*Citrus grandis* Osbeck) in Bengal. Jenkins (1936) also records this fungus on the fruits of *Hesperethusa crenulata*, in Bengal again, the host being a distant relative of the *Citrus* group. The identification was based on material sent to Dr. W. T. Swingle by the curator of the Royal Botanical Gardens, Calcutta. It is apparent from the above account that only *Sphaceloma Fawcetti*, the conidial stage of the sour-orange scab, has been recorded in India and that the ascigerous stage for this or any other species of *Elsinoë* previously has not been reported.

In the course of collecting the fungous flora around Nandi Hills, Mysore State, the writer came across an *Elsinoë* on *Scutia myrtina* Kurz., a member of the Rhamnaceae, which appeared to be undescribed. Further detailed studies undertaken by the writer con-

firmed this surmise. The fungus differed entirely from *Elsinoë Hansfordii* Jenkins & Bitancourt (1942), described on the same host species from Uganda, as well as from any other species so far known. For microscopic examination the material was fixed in formalin-acetic-alcohol, and the microtome sections that were cut were stained with Heidenhain's iron-alum haematoxylin with orange G in clove oil as counter stain.

The infection spots, which are mostly found on the leaves and petioles and very rarely on tender shoots, first appear as tiny black specks gradually expanding into a patch. There is no sign of any hypertrophy or formation of blistered warts as in the case of *Elsinoë Hansfordii*. On the other hand, the ascomata is epiphyllous forming a jet black epitheciium composed of dark hyphal cells and host cells. The affected regions are slightly thicker than the non-infected portions. The *Sphaceloma* stage is not found in association with young ascomata and was seen first only in the culture obtained from the ascospores. Further search among the infected plants revealed that the *Sphaceloma* stages are of rather rare occurrence. The leaf lesions in such cases are yellowish brown, amphigenous and erumpent. Sections through the acervuli indicate that the fundaments of the sori are first organized by the concentration of the hyphae within the epidermis (FIG. 2). Very soon, a palisade layer of conidiophores is differentiated and these cause the rupture of the upper wall of the epidermis and the cuticle. The sori are thus intraepidermal and the conidiophores abstrict ovate to globoid conidia in succession (FIG. 3). The conidiophores are cylindric, 30–50  $\mu$  long, somewhat tapering at the ends and thin-walled. The conidia are ovate subglobose, hyaline, thin walled, one-celled and measure 8–10  $\times$  4–5  $\mu$ .

Sections through the young ascomata also reveal that the fundaments of the sori are organized by the concentration of dark hyphal cells within the upper epidermal cells and thus are intraepidermal in origin. The asci are subglobose to spherical, embedded within the stroma, and disposed in two to three layers (FIG. 7). Microconidia have not been observed as yet.

The studies on the sexual life cycle of the fungus are as yet incomplete. The young ascus is spherical, double-walled, and shows a large fusion nucleus (FIG. 4). By three successive free nuclear

FIGS. 1-7. *Elsinoë Bitancourtiana*

divisions an 8-nucleate ascus is produced, the nuclei being disposed approximately equidistant from one another. Following the differentiation of cleavage furrows, eight young ascospores are produced (FIG. 5). These are at first spherical and uninucleate. The nucleus within each spore divides followed by periclinal wall formation. At this stage the ascospores appear to be filamentous showing three transverse septa. By the initiation of anticlinal divisions in the upper three cells, the ascospore becomes muriform (FIG. 6). The mature ascospores are therefore cuneate, being broader at the apex than at the base, multicellular, muriform, thin walled, and measure  $25-31 \times 12-15 \mu$ .

Studies of the fungus were also made in artificial cultures. For obtaining the cultures a suspension of ascospores in sterile distilled water was made on slides and allowed to dry. Transfers of these ascospores were made with a dry sterilized needle to agar slants. Colored gummy growth of the fungus producing the *Sphaceloma* stage led the writer to search for the conidial stage in nature also. Comparisons in shape and measurements between the conidia produced in culture and those obtained by natural infection indicated that they were identical.

As to the identity of the species of *Elsinoë* under study, it is apparent that there is considerable difference between it and *E. Hansfordii*. Although both occur on the same host, *E. Hansfordii* causes malformations of the host tissue in the form of gall-like excrescences. The presence of a black epithecium, so characteristic of the present species, is absent in *E. Hansfordii*. Mature ascospores have not been observed for *E. Hansfordii* so no comparison can be made with respect to this feature. The writer proposes to present the fungus described in this study as a new species and the name *Elsinoë Bitancourtiana*, in honor of Dr. A. A. Bitancourt, Sao Paulo, Brazil, who has considerably advanced our knowledge of the group, is proposed.

### ***Elsinoë Bitancourtiana* Thirumalachar sp. nov.**

Plures infectionis maculas producens in foliis, petiolis, sed raro in culmis teneribus, dispersas, ut plurimum epiphyllas, gradatim crescentes atque simul confluentes, circulares ad irregulares, 3-5 mm. in diam., aliquantulum elevatas supra foliorum faciem, numquam hypertrophiam producentes. Asco-



mata epiphylla, intraepidermalia atra ob epithecium structum hyphis obscuris atque cellulis plantae parasitatae; asci bis vel ter-seriati, hyalini, tenui pariete praediti, intus stromati infixi, ovati ad sphaericos,  $38-55 \times 30-40 \mu$ , 8-sporei; ascosporae ellipsoideae, latiores ad apicem quam ad basim, tenuibus parietibus praeditae, initio 4-septatae, postea muriformes ob efformatos muros verticales, magnitudinis  $25-31 \times 13-15 \mu$ . Infectionis maculae in *Sphacelomatis* statu amphigenae, luteo-brunneae, haud hypertrophatae, erumpentes atque pulverulentae. Acervuli intraepidermales, conidiophoris in serialibus vallatis dispositis atque epidermatis superiorem faciem erumpentibus, saepe continui ob coalescentiam; conidiophori quater vel sexies longitudine majores quam latitudine, cylindrici, acuti in apice, ad  $30-50 \mu$  longi, acrogena successione efformates, conidia hyalina; conidia ovata ad sphaerica, tenuiter parietata, magnitudinis  $8-10 \times 4-5 \mu$ .

In foliis atque petiolis sed raro in culmis teneribus *Scutiae myrtinae* Kurz., Nandi Hills, Mysore State, 16-11-1944, leg. M. J. Thirumalachar (Type), Burudalbare, Hassan District, 26-4-1945, and Jalahalli, Bangalore, 18-10-1944.

Infection spots numerous, on leaves and petioles and rarely on tender shoots, circular to irregular, 3-5 mm. in dia., enlarging and becoming confluent with one another, jet black on account of the epithecium composed of dark hyphae and host cells, never hypertrophied, showing pustulate appearance on the surface. Ascomata epiphyllous, intraepidermal, black on account of the epithecium, asci two to three layered, embedded within the stroma, subglobose to spherical, double-walled,  $38-55 \times 30-40 \mu$  and 8-spored; ascospores ellipsoidal, broader at the apex, thin walled, four-septate in the early stages, later on becoming muriform due to the formation of vertical septations and measuring  $25-31 \times 13-15 \mu$ . Infection spots of the *Sphaceloma* stage amphigenous, yellowish brown, erumpent and not hypertrophied; sori intraepidermal with palisade layers of conidiophores rupturing the upper wall of the epidermis; acervuli often coalescing to form a continuous layer; conidiophores cylindric,  $30-50 \mu$  long, developing acrogenously in succession hyaline conidia. Conidia ovate to spherical, one-celled, thin walled, hyaline, measuring  $8-10 \times 4-5 \mu$ .

On living leaves of *Scutia myrtina* Kurz., Nandi Hills, Mysore State, 16-11-1944, leg. M. J. Thirumalachar (Type), Burudalbare, Hassan District, 26-4-1945, and Jalahalli, Bangalore, 18-10-1944. Type deposited in the Herb. Crypt. Ind. Orient., New Delhi, in the Imperial Mycological Institute, Kew, England, and in the Instituto Biologico, Sao Paulo, Brazil.

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# EXPLANATION OF FIGURES

- FIG. 1. Photograph of infected leaves  $\times$  about natural size.
- FIG. 2. Organization of the intraepidermal sorus of *Sphaceloma*  $\times$  800.
- FIG. 3. Section through an acervulus showing the conidiophores and conidia  $\times$  800.
- FIG. 4. Ascus with fusion nucleus  $\times$  800.
- FIG. 5. Ascus with 8 immature ascospores  $\times$  800.
- FIG. 6. Stages in the development of the muriform ascospore  $\times$  1800.
- FIG. 7. Photomicrograph showing the asci with ascospores within the stroma  $\times$  500.

## NOTES AND BRIEF ARTICLES

### A CORRECTION

In the article A New Species of *Lysurus*, *Mycologia* 37: 782. 1945, the figures 5 and 6 are reversed. Number 5 shows the outer side of the tip of an arm and no. 6 the inner.—W. C. COKER.

### RUSSULA INCONSTANS MURRILL

This was published in *Lloydia* 8: 266. 1946 as a new Florida species. Miss Burlingham writes me that she used this name in *Mycologia*, 1936 for a new species from Oregon. I therefore propose for my Florida plant the new name *Russula subinconstans* Murrill.—W. A. MURRILL.

### INOCYBE HEBELOMOIDES MURRILL

Through an unaccountable error this species was published twice, first in *Proc. Fla. Acad. Sci.* 7: 2 and 3. 121. 1944, and again in *Jour. Fla. Acad. Sci.* 8: 2. 188. 1945. The descriptions are identical and refer to the same herbarium material.—W. A. MURRILL.

### DR. JAKOB E. LANGE, 1864–1942

A letter from Morten Lange to Prof. L. R. Hesler a short time ago contained the information that Dr. Lange died "at the New Year, 1942." In his death our Society has lost one of its most distinguished members. Many of us knew Dr. Lange personally as a result of his visits to the United States, and treasure our memories of collecting trips with him in search of fungi. Those interested in the agarics, Dr. Lange's specialty, feel that his passing represents the greatest loss that could come to their field of interest at the present time. Morten stated that had his father been

alive during the last days of the war he would have been in constant danger. Mrs. Lange passed away in 1943. A more detailed biographical sketch will appear in MYCOLOGIA in due time.—ALEXANDER H. SMITH.

#### A NEW SPECIES OF HYDROPUS (KÜHN.) SING. (AGARICALES)

*Hydropus* is a grouping proposed by Kühner and given the rank of a genus by Singer. It contains several closely related species easily recognizable under the microscope, and after some experience also in the field. In addition to the species formerly indicated for this genus, I have recently discovered a sub-tropical species closely allied to *H. Sabalis* Sing. which is white and grows likewise on *Sabal palmetto*. The new species here named *H. frater-niger* (the black brother) grows exclusively on dead leaf-petioles and in detritus between them or on wooden matter beneath them, always of *Sabal palmetto*, in low hammock vegetation. It differs from the other *Sabal*-inhabiting species in being black instead of white. It is closest to the bisporous form of *Hydropus marginellus* (Pers. ex Fr.) Sing. from which it differs in being darker colored, astriate and later sulcate on the pileus, by never becoming depressed except in dried condition, in having pallid white lamellae which are more distinctly decurrent-descendant, and in the constantly unequal stipe (which tapers downward). It is also slightly smaller in its general measurements if average specimens are compared.

*Hydropus frater-niger* Sing. spec. nov. Pileo subnigro, manente aterrimo in centro, ad marginem subpallente in vetustis et in siccis, convexo, subumbonato vel umbonato, numquam depresso nisi in exsiccatis ad ipsum discum, levi sed ad marginem demum sulcato, vix striato in plurimis, brevissime striato in exsiccatis, 6-9 mm. lato; epicute e dermatocystidiis versiformibus, inflatis, subvesiculososis vel late fusoideis, saepe subampullaceis, ascendentibus vel saepius erectis corticem subhymeniformem dense continuam efformantibus, intus succo e pigmento dissoluto umbrino repletis consistente; hypodermio ex hyphis repentibus, subparallelis, item coloratis, elongatis consistente; nequidem gelatinascente. Lamellis albidis vel albis, mediocriter latis (1.5 mm. latis), moderate distantibus (18 fere lamellis integris praesentibus), descendantibus, demum subhorizontalibus sed semper distincte decurrentibus; sporis hyalinis, membrana levi amyloidea instructis, depressione suprahilari praeditis vel appanatione tantum gaudentibus,  $8.5-9.5 \times 5-5.5 \mu$ ; basidiis  $28-31 \times 6.5-7 \mu$ , omnibus bisporis; cheilocystidiis dermatocystidiis pilei simillimis. Stipite

griseo, vel griseo ad basin et albo ad apicem, interdum minutissime albo-pruinoso ad apicem e dermatocystidiis stipitis, constanter attenuatis basin versus, levi, pruina excepta glabro,  $21-22 \times 1-4.5$  mm. Carne exigua; odore nullo; sapore haud notato; hyphis tramatis haud amyloideis, fibulatis; tramate lamellarum ex hyphis plerumque filamentosis, subregulariter dispositis consistente. Ad truncos palmarum tantum (*Sabal palmetto*) vivarum gregatim in dumetis palustribus subtropicalibus Floridae meridionalis. Typus (Singer, F643, FH) in Highlands Hammock State Park, Highlands County collectus erat.

R. SINGER.

#### TIME SAVING IN THE PREPARATION OF CORN MEAL AGAR AND IN THE IDENTIFICATION OF YEAST-LIKE FUNGI

##### I

Ajello<sup>1</sup> recommends the use of a "Silex Type" coffee maker with a Cory glass filter rod in order to save time in the preparation of corn meal agar. This method has the advantage of using a simple device that may be at hand in most kitchens. The disadvantage is that the mixture has to be passed and repassed at least eight times, and that the extraction of the corn meal takes place at a temperature exceeding substantially the 60° C. of the original method.

I have been using for years another method of reducing the time affecting only the modus of filtration. Twelve and one-half grams of yellow corn meal in 300 ml. of water are heated in a water bath of 60° C. for an hour, then poured into a porcelain filter containing Whatman filter paper No. 3. A suction pump attached to the water faucet draws a clear filtrate within a few minutes. The volume of the extract is measured, brought back to 300 ml. and added to the amount of agar needed (3.8 gm. of the prewar quality of Bacto agar, 3.0 gm. of the new agar). This is autoclaved at 15 lbs. pressure for 15 minutes in order to dissolve the agar, again filtered as described above and filled in tubes. These are autoclaved at 15 lbs. pressure for 15 minutes before they are slanted.

This method was checked repeatedly with corn meal agar prepared according to the original method. The results were the same. However, the preparation time has been reduced to two and a half hours.

<sup>1</sup> Ajello, L., A simple method for preparing corn meal agar, *Mycologia* 37: 636-637, (Sept.-Oct.) 1945.

## II

I have been using slants instead of Petri dishes for the identification of yeast-like fungi. The platinum needle inoculated from a colony is stabbed between the slanted agar and the wall of the tube. *Candida albicans* develops numerous filaments and quite a number of chlamydospores at room temperature (25° C.) within 24 hours. Since the stab culture just described develops near to the wall of the tube, filaments as well as chlamydospores are easily observed with the help of the low power lens.

The original method of searching for the chlamydospores in a Petri dish takes more time and may lead to contamination of the culture.

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\* Dr. Bernhardt died suddenly, Feb. 27, 1946—Editor.

## NOTICE

Please communicate to the Secretary, **at once**, any change of address.

FREDRICK K. SPARROW, JR., *Secretary*,  
Botany Dept., Univ. Mich.,  
Ann Arbor, Mich.



E. W. D. HOLWAY, 1853-1923.

# MYCOLOGIA

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E. W. D. HOLWAY

1853-1923

A BANKER'S AVOCATIONS

JOHN DEARNESS

Recently when studying some micro-fungi, which Professor Holway had reached by arduous climbing on a mountainside, skillfully mounted and photographed, the writer's thoughts were turned from the collection to the collector along the lines of the nature and value of a good avocation. The word does not need to be defined, but it may not be out of place to think in passing of its meaning. In modern civilized society people apportion their waking hours between work and leisure. In other words, work and play—vocation and avocation. Work is activity motivated by the expected result often called wages; play is activity motivated by the enjoyment of the action. It is natural and reasonable that a worker, knowing that continuous idleness is not conducive to either health or happiness, should dread compulsory retirement from his vocation. He can truly say, "Blessed is the man who can find satisfaction in the pursuit of a worth-while avocation." Such a man was the late Edward Willet Dorland Holway. His life was noteworthy in both vocation and avocation.

**HIS YOUTH.**—It might be said that he was a native of two of the United States, having been born in the county town of Lenawee in southeast Michigan, moved in infancy in the prairie covered wagon to the county of Winnieshiek in northeast Iowa and educated in its county town, Decorah. His aptitudes and progress at

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school encouraged his parents to consider plans for his education that would lead to a professional life but his illness prevented the execution of them. In boyhood his health was frail; this was one reason why his mother took him on frequent outdoor trips to the fields and woodlands of the district. Another reason was to make him a sharer of her interest in nature.

Like many boys, he had a natural liking for making collections of different classes of objects, perhaps preferably of plants and flowers, which continued throughout his life; indeed in later years when he concentrated his attention on the parasites of plants, especially the Uredineae, the interest strengthened to a passion on which he spared neither labor nor expense. It is a measure of his success that the University of Minnesota is indebted to him for a gift of over 19,000 specimens.

MICROSCOPY.—The study he put upon the micro-fungi commonly known as plant-rusts, or technically, Uredineae, demanded a great deal of critical labor and a high degree of skill in two arts; namely, microscopy and photography. Either of them has been the satisfying life-avocation of some men.

Evidence of the superlative proficiency he acquired in these arts is found in a publication by the University of Minnesota Press entitled Holway's *North American Uredineae*. It appeared in five sections from 1905 to 1924, containing the history, description and distribution of 181 species with 54 plates, 11" × 8", each showing six lithographed photographs of spore groupings, most of them magnified five hundred times the natural size. It was of this work that Dr. J. C. Arthur wrote: "The perfection of Professor Holway's micro-photographic work is especially shown in the case of spores with thick dense walls and delicate, colorless pedicels." As an illustrated and dependable authority on nearly two hundred American plant-rusts, this treatise is likely to remain without a peer for a long time. It will always be the chief monument of Professor Holway's achievements in the science of botany.

MOUNTAINEERING.—A fourth avocation in which an honorable and permanent reputation, branched from his interest in plant hunting, was mountain exploring. How it originated is quoted by the late Howard Palmer from one of Holway's letters in *A pioneer of the Canadian Alps*. "The summer of 1901 was the

hottest ever known in Decorah. The thermometer stood at 106° F. I had not had my week's vacation, so I took the atlas to find the nearest place likely to be cool and selected Banff in the Canadian Rockies." Anticipating abundance of plant species in the British Columbia valleys, he started for Banff with hardly any other equipment than his purse and a plant press. Passing from Banff without delay to Lake Louise, he met and conversed with a mountain guide. The result of the meeting was that next morning, before sunrise, the guide with his rope and the would-be mountain climber with ice axe were on their way to climb Mt. Victoria. The sun rose in a clear sky but soon black clouds gathered; a thunderstorm became a snowstorm so dense that they could hardly see each other or where to step. They continued slowly, the snow changed to rain. Perseverance was rewarded. Before they saw Lake Louise again the guide had used the rope—Holway the ice axe, besides getting lessons in fording mountain streams and drying clothes in front of a wood fire. Mt. Victoria afforded enough climbing for the week and much experience to think about.

Not discouraged and better prepared, he was, on the first day of the next summer vacation, back at Lake Louise engaging the only guide there at the time. In this week he climbed both Mt. Hector and Mt. Temple, traversed Abbott Pass, sleeping two nights in the open air without a bed.

Mountaineering was now another hobby—the fourth. Dangerous risks became only challenges to his courage, strength and increasing skill. Limit of space bars the recital of some of his recorded experiences but gleaned phrases will suggest contexts: an avalanche of snow—on Mt. Geikie two rocks rolled down on my leg—food exhausted—after the cold night killed a porcupine, ate the liver and quarters without salt—a hardly visible crevasse—a grizzly bear and her two cubs—on Grizzly Creek our two pack horses fell off, one rescued, the other had to be shot—two people on Mt. Rainier without guide or ice axe, \$1,000 reward, never seen or heard of since.

Some of the compensatory delights are suggested by phrases in his letters, such as—"most delightful trip—a glorious glacial trip—scenery unsurpassed—am sixty-one and I never felt better—an

appetite to be proud of—it is October now; I am just existing until next July.” His physical fitness must have been well preserved when a mountaineering companion of his trips could say, “Holway is made of India rubber and steel springs.”

For plant collecting, assisted by his wife, he enjoyed exploring the mountain valleys of Central and South America, but for the joy of mountaineering he always returned to the Canadian Rockies, particularly to the glaciated peaks of his “beloved Selkirks” in the Big Bend of the Columbia River. There he made the first known ascent of several peaks. His name as a first ascender is associated with the one commemorating the heroic nurse, Edith Cavell, who was judicially murdered by the Germans. Another mountain rising over ten thousand feet near the crossing of  $118^{\circ}$  west longitude and  $51^{\circ} 30'$  north latitude, bears on map no. 237A of the Geological Survey of Canada the name of Mt. Holway. His name is also used for a stream discharging at last into the North Illecillewaet River. His annual papers, contributed from 1909 to 1918 to the Canadian Alpine Journal, vols. II–IX, made important extensions of the knowledge of the Big Bend region. He is credited with making forty-eight ascents of Albertan and British Columbian mountains, many of them without guides. “On the roll of pioneers in the Rockies and Selkirks, his name will ever hold an honored and distinguished place”—Howard Palmer.

**VOCATIONAL LIFE.**—As already stated, plans for a collegiate education of young Holway were frustrated. While yet within school age it happened that the manager of the only bank in Decorah offered him employment in the bank. His acceptance of the initial duties led him to adopt banking as his vocation. Step by step he climbed the ladder from messenger to manager.

The years passed I can imagine him saying to himself in 1903 —“I am now fifty years old. For thirty-five years I have worked in the confining routine of this office. I have made a success of the bank and saved a competence upon which I can retire. My health is good yet. My happiest hours are those of my leisure in my garden, in fields and by streams, studying plants and flowers. This seems to be a good time to retire from the office and enter on a life free from care and rich in enjoyment.” He announced his intended retirement to his surprised customers, who urged

him to reconsider his intention. Even with the admitted view of dollars on the horizon, he said to at least one friend that he "would rather be a living worker in the field of science than a dying millionaire."

In 1904 he had left Decorah and settled in Minneapolis near the University of Minnesota. His scientific library and important herbarium were donated to the University. There he had been given a room suitable for a laboratory with access to the facilities of the University for research and the rank of honorary Professor of Botany. The work there and in his new garden was real happiness. His time was at his own disposal; he was free to make those long collecting trips of which he had but dreamed.

**HOME LIFE.**—Having in mind the amount of outdoor work he accomplished in his spare time in Decorah, one might wonder whether he had any home life. His fellow citizens must have thought he had spare time as well as interest in the education of his two daughters when they elected him to serve on the Board of Education. Dr. J. C. Arthur, an intimate friend for many years, can be cited in these words: "On different occasions while Professor Holway lived in Decorah, it was my pleasure to have been a guest in his home where I had the privilege of meeting his family and his wife, née Effie Aiken, a woman of fine taste in many different lines, whom he married in 1876 and of whom he was bereft in 1917. The family had a splendid home life." On the 12th of December, 1918, he married Mary E. Mortenson. She was a graduate of the University of Minnesota, "a woman of splendid physique, rare ability and fine poise, an enthusiastic and intrepid companion." She accompanied him helpfully in his South American explorations and supervised the completion of the last volume of his *North American Uredineae*.

**BIBLIOGRAPHICAL.**—A complete bibliography of American fungi with whose names that of E. W. D. Holway is associated as discoverer or describer would fill pages. The following is a brief review:

In the *American Naturalist* 17: 192–196, 1883, there is an article by J. B. Ellis, of Newfield, N. J., entitled *New species of North American fungi* in which E. W. D. Holway is credited with discovering eleven new species in the Decorah district from May to

October, 1882. One of the species is named *Hypoxyylon Holwayi*; another was later raised to the rank of a genus and renamed *Holwaya* by Saccardo in *Sylloge VIII*, p. 646. Mrs. Mary M. Holway is honored in the name *Holwayella*, proposed by Dr. H. S. Jackson for a new genus of South American rusts. The name recognizes the importance of her work in the South American explorations.

Volume I of the *Journal of Mycology* appeared in 1885. The second article in this volume was *New fungi from Iowa* by J. B. Ellis and E. W. D. Holway. They are joint describers of fifteen new species all collected by Mr. Holway in the vicinity of Decorah, mostly in 1884. Not one of the twenty-six was a plant-rust. Every description included critical microscopical examination.

I have not found the date of, nor reason for, his specializing on the Uredineae. It was probably owing to Dr. Arthur's influence. *Puccinia areolata* was described by Dietel and Holway in 1894. Holway's series of *Notes on the Uredineae* in the *Journal of Mycology* was begun in 1902 and the first volume of his masterpiece, *The North American Uredineae*, was dated April 15, 1905; the others followed on May 15, 1906; May 10, 1907; June 11, 1913; and the fifth and last on July 2, 1924, fifteen months after his death.

Besides Paul Dietel, the most helpful of the Germans, other authors collaborating with him were: Paul and Hans Sydow, J. B. Ellis, Dr. J. C. Arthur, W. H. Long, and Dr. H. S. Jackson.

**Arthur, J. C.** The grass rusts of South America; based on the Holway collections. *Proceedings of the Amer. Phil. Soc. LXIV*, no. 2: 131-223, 1925. 10 photo-prints of spore groups. 74 species. Rust index and host index.

———. *Uredinales of Costa Rica*; based on collections made by E. W. D. Holway. *Mycologia* 10, no. 3: 111-153. 1918. 118 species.

**Jackson, H. S.** The rusts of South America; based on the Holway collections I. *Mycologia* 18, no. 4: 139-162. 1926. 1 plate. Species nos. 1-49.

———. *Ibid.* II. *Mycologia* 19, no. 2: 51-65. 1927. Species nos. 50-82.

- . *Ibid.* III. *Mycologia* 23, no. 2: 96–116. 1931. 4 figs., 1 plate. Species nos. 83–99.
- . *Ibid.* IV. *Mycologia* 23, no. 5: 332–364. 1931. 6 figs. Species nos. 100–167.
- . *Ibid.* V. *Mycologia* 23, no. 6: 463–503. 1931. Species nos. 168–250.
- . *Ibid.* VI. *Mycologia* 24, no. 1: 62–186. 1932. Species nos. 251–468.

The descriptions of new species of fungi bearing the name "Holway" as discoverer or describer, totalling hundreds, were published in several scientific journals, mostly in English, some in German. Most of the descriptions dating prior to 1930 were reproduced in Latin in Saccardo's *Sylloge Fungorum*. A few early examples are cited here:

*Holwaya gigantea* (Peck) Durand, Coll. 1883, in Iowa.

*Uromyces Holwayi* Lagerheim, on *Lilium superbum*, 1889, Ann Arbor, Mich.

*Puccinia Holwayi* Dietel, on onion, 1893, in California.

*Uraecium Holwayi* Arthur, on hemlock, 1906 (1933), in Alaska.

*Ravenelia Holwayi* Dietel, 1894, in Texas.

*Uropyxis Daleae* Dietel & Holway, 1897, in Mexico.

*Prospodium Holwayi* Jackson, in Feb., 1922, in Brazil.

Citations from the *American Naturalist* 17, 1883, and the *American Journal of Mycology* 1885 are made on a preceding page.

EXSICCATI.—The *North American Uredineae* and the numerous papers he published do not complete his legacy to science. Dr. J. Arthur Harris, the head of the Department of Botany in the University of Minnesota, believed that the large amount of duplicate material Holway had collected should be made as widely useful as possible. His widow, Mrs. Mary E. M. Holway, who had been the companion and assistant in Professor Holway's botanizing trips since 1918, was competent and willing to assort the material into labeled sets. It was found that there was enough of it to make up twenty-five sets of seven hundred specimens in each set called *Reliquiae Holwayanae*. Of these sets, two are now in Japan, five in Germany, one in Stockholm, one in the British Museum, twelve in America, besides the four yet in Mrs. Holway's possession. Every description involved critical microscopical examination.

EPICEDUM.—With his objective still not completely achieved, March 1923 found Professor Holway in Phoenix, Arizona, planning trips in equatorial South America, particularly in the highlands of Ecuador. Fate was against him. On the last day of the month a valvular irregularity blocked forever the vital action of that tireless heart.

In his lifetime he was known to approve of the crematory disposition of lifeless bodies. His devoted wife made the long trip to the Asulkan Valley to lay his ashes in a favorite spot beneath the noble evergreens where, in the words of Howard Palmer, "solemn silences and cool sylvan shadows hold perpetual sway, while overhead the feathery fingers of the graceful branches point constantly to the snowy peaks he loved so well."

In his vocation as a banker his success will be honorably remembered for a lifetime. In his avocations his name and his fame as a Uredinologist will endure as long as the literature of botanical Mycology. Good maps of the Canadian Rocky Mountain region will always show the location of Mt. Holway.

ACKNOWLEDGMENTS.—My personal contacts with Professor Holway were limited to correspondence about plant rusts and reception of specimens from some of his valuable collections. For the portrait used as a frontispiece, for letters and consultations, I am indebted to my friend, Mrs. Ruth Holway Higgins, his younger daughter and onetime Secretary of an Ontario Authors' Association; for some unpublished information to his widow, Mrs. Mary E. M. Holway, whose work in the production of Part V of the *North American Uredineae* is beyond praise.

#### USE WAS MADE OF THE FOLLOWING PUBLICATIONS

*Edward W. D. Holway, a pioneer of the Canadian Alps*, by the late Howard Palmer, F.R.G.S., President, American Alpine Club, a onetime mountaineering companion.

Introduction of fourteen pages to *Grass rusts of South America* by Dr. J. C. Arthur, long an intimate friend who was able to say, "Whatever Holway undertook he always did unusually well." In the Introduction to *Reliquiae Holwayanae* the late Dr. Arthur Harris, Head of the Department of Botany of the University of

Minnesota, said of Holway, "Widely known for the critical nature of his collecting and the skill shown in his microphotographic illustrations."

*Prominent men I have met, E. W. D. Holway*, by L. H. Pammel, B.Agr., D.Sc., of Iowa State College, "It is probably correct to say he discovered more new plant rusts than any other botanist."



# PROPOSALS CONCERNING THE NOMENCLATURE OF THE GILL FUNGI INCLUDING A LIST OF PROPOSED LECTOTYPES AND GENERA CONSERVANDA

ROLF SINGER AND ALEXANDER H. SMITH

*Nomenclature is the handmaiden of taxonomy, not the mistress.*

R. Ramsbottom, Trans. Brit. Myc. Soc. 25 (4): 439. 1942.

The taxonomist frequently finds himself burdened with difficult or insoluble problems of nomenclature which occupy time that he could more profitably devote to a study of the organisms themselves. Even though he arrives at the correct solution of a nomenclatorial problem, the result may be unfortunate, for it often happens that after a prolonged historical study and search for the valid name of a species, the one arrived at is not recognized by any mycologist. For instance, if the International Rules are followed, *Cortinellus flavovirens* is the valid name for the fungus we commonly call *Tricholoma equestre*. As an isolated instance this situation is unimportant. If, however, after careful study it is found that the number of changes which obviously work against the fundamental precept of the rules, i.e. the stabilization of commonly used names, is great, then it is logical to assume that something must be wrong with the rules as they are—at least as they apply to the gill fungi.<sup>1</sup> In our estimation this is unquestionably true at present.

The nomenclature of this group is unstable and confused for several reasons. In our estimation the four most important are:

(1) Strict application of the International Rules of Nomenclature is impossible as long as the names of the older genera such as those established by Quélet and Karsten remain applicable to more than one emended genus because of the lack of an officially chosen

<sup>1</sup> The term *gill fungi* as used here applies to the lamellate species of the Agaricales and is not intended to designate a taxonomic unit.

and accepted type species (*species lectotypica*, or *lectotype* as we shall designate it in the following discussion) for each of them (cf. Art. 51 and Art. 21, note 2, of the International Rules of Botanical Nomenclature). Because of the lack of lectotypes many generic names, as for example *Lepista*, have been used for different generic groups to the confusion of all who study the literature.

(2) Strict application of the rules would change the names of several well established and important genera such as *Clitocybe* and *Cortinarius* with scores or even hundreds of common and important species. The chief source of this difficulty is that S. F. Gray's *Natural arrangement of British plants*, 1821, is now known to be a post-Friesian publication (cf. Art. 20, f).

(3) The conservation of genera does not always find unanimous approval because of the existence of several schools of thought. For instance, there is a conservative school which follows Bresadola and is chiefly represented in Germany, England, and Italy; a second school advocating smaller and more homogeneous genera according to the principles of Fayod and Patouillard; and finally a third group still following the old American Code. The conservation of a name may be advantageous (from the standpoint of mutual understanding and continuity) for one school though disadvantageous from the point of view of one of the others (see *Marasmius* and *Rhodophyllus*). The overruling of the legitimate needs of any of these groups by a small and accidental majority of an International Congress appears to us to be both unfair and unwise, and certainly does not increase the moral authority of the International Rules. And let us not forget that moral authority is the only compelling factor involved after the rules have been made.

(4) Definite confusion exists concerning the use of the Friesian subgenera and tribes as genera. There is a tendency to consider these equivalent with the genera of Quélet and Saccardo<sup>2</sup> and there is also something like a common usage in Europe which neglects to indicate the name of the author who first transferred a species from *Agaricus* to one of the generic names raised from the

<sup>2</sup> See Bisby, Who is the author? Trans. Brit. Myc. Soc. 25: 434-435. 1942. Also Dodge, C. W. Proposals of amendments of Article 20 of the International Rules of Nomenclature.\*Ann. Mo. Bot. Gard. 21: 709-712. 1934.

original Friesian subgenera or tribes. Also, doubts have arisen as to the necessity of limiting ourselves in the choice of a lectotype to the species enumerated by the author who first treated a particular Friesian subgenus or tribus as a genus.

As already pointed out, by far the most important shortcoming is that named under (1). In fact, the absence of lectotypes in most older genera makes it impossible at times for the seriously minded and conscientious taxonomist to proceed with his studies in an orderly manner. Furthermore, the difficulties mentioned under headings (2) and (3) are very closely related to the lack of a complete list of lectotypes.

As for generic names, we believe that a reasonable weighing of the arguments for and against conserving certain names and an intelligent selection of lectotypes will establish a system of generic types which will form an acceptable basis for taxonomic work by representatives of all schools who accept the framework of the International Rules. It is not necessary, for instance, to outlaw all of Gray's genera. Some merely involve the use of an already accepted name and the only change necessary is that of the authority. Genera likely to lead to undesirable changes can either be reduced to synonymy by the proper selection of a lectotype or rejected in favor of certain nomina conservanda. We do not need to suppress the tendencies of one taxonomic school in favor of the other, for there are always more favorable ways if both points of view are considered.

Undoubtedly the most impartial way of finding out which solution of two or several possibilities is more practical for all of us is the arithmetical approach applied with some judgment and after consideration of all factors involved. If, for instance, a part of the French school of taxonomists (Romagnesi) prefers the genus *Drosophila* to what Kühner and A. H. Smith call *Psathyrella* emend. then we must ascertain quantitatively which solution—*Drosophila* or *Psathyrella*—has fewer ill consequences. The most outstanding ill consequence of a nomenclatorial change is the necessity of a high number of transfers. The number can easily be established at least approximately. Of course, it may be necessary to make some allowance for the relative importance of the species concerned. In our example, if *Drosophila* should be considered as

a candidate for the list of *nomina proposita conservanda* against the legitimate name *Psathyrella*, many more new combinations would have to be made than would be necessary by simply accepting the latter genus in the emended concept. We prefer this latter alternative. It does not take anything away from the very sensible solution proposed by Quélet at a time when the affinity of these elements with each other was extremely hard to recognize. Those who work in this group will appreciate Quélet's contribution under all (nomenclatorial) circumstances; those who do not will be unable to appreciate the value of his contribution regardless of whether *Drosophila* Quél. or *Psathyrella* (Fr.) Quél. becomes the accepted name.

As for the difficulties enumerated under (4), one must study the pertinent facts and consider the consequences of each proposal before forming an opinion. What would happen if Fries' sub-generic and tribal names were considered as genera? To ascertain the results of such a proposal the first thing to decide is which of Fries' publications shall be used as the legal basis or starting point, for he made many nomenclatorial changes during his life, and thus the names which shall be raised legally to the status of genera must be taken from a single publication. If *Systema Mycologicum* vol. 1 is selected as the starting point, as has been done already, it will no doubt surprise some to find that certain of the newly decreed generic names are entirely different from those we know from Saccardo and which for some reason have generally received preference. As an example *Galorrheus* would take the place of *Lactarius*. This shows how carefully one should study the literature and how much depends on a real working experience in a given group if sensible proposals are to be expected. In a later work of Fries the discrepancy between our present nomenclature and his would be less embarrassing, but then the whole problem, including the system of citing the authority, would not become simpler but more complicated, and basic changes would need to be made in the present International Rules. It appears to us that now it is more desirable to establish an orderly system of selecting generic names within the framework of the present rules than to try to revamp them completely and thus risk even worse confusion than that existing at present.

A strict application of the existing rules requires that an author-citation for a species should be made up of the original author of the species and the name of the investigator (or compiler) who transferred it to the presently accepted genus. Although we do not feel that Fries or any other investigator should be made an exception to this rule, we do believe that mycologists primarily engaged in non-monographic studies such as local floras need not feel obligated to be consistent with the present letter of the International Rules when monographs of the genera in question are lacking. In other words, we would be tolerant of citations such as *Mycena pura* (Pers.) Fr. instead of *Mycena pura* (Pers. ex Fr.) Quél. In fact it may be well to recommend this way of citation as the next best in order to discourage worse habits, but they should be limited for certain purposes and on a temporary basis.<sup>3</sup>

As for the question of whether or not it is proper to choose a lectotype from a work other than the one in which the Friesian tribe or subgenus is first cited as a genus, we may say that this depends on the definition the respective author gave of his genus. In the case of Quélet who is actually the most important author to be considered in this connection, we want to direct the attention of mycologists to a footnote in "Les Champignons du Jura et des Vosges," p. 60 of the first edition. The footnote reads: ". . . La classification et la synonymie sont celles de Fries, *Summa Vegetabilium Scandinaviae* et *Monographia Hymenomycetum Sueciae*. J'ai cru nécessaire d'élever au rang de genres, les sous-genres de Fries. . . ." This statement makes it absolutely clear that we are entirely within our rights if we choose a lectotype from either of the following two works: Fries, E. M. *Summa Vegetabilium Scandinaviae*, 1846-49; or Fries, E. M. *Monographia Hymenomycetum Sueciae*, 1857-63. We have made this one of the principles of our proposed list of lectotypes for all genera which were not unmistakably provided with a type species by their authors.

Other self-imposed rules which we thought to be helpful in order to achieve a solution least harmful to the stability of accepted generic concepts are the following:

<sup>3</sup> See also R. Heim, *Fungi Iberici*, *Treb. del Museu de Ciències Naturals de Barcelona* 15 (3): 16. 1934.

(1) The lectotype must, of course, comply with the requirements of the type method by being one of the species *originally* included in the genus or the group on which the genus was based.

(2) The lectotype should be selected in a way that avoids both substitution of little known names for well established genera <sup>4</sup> and the unreasonable increase of the list of genera conservanda.<sup>5</sup> This cannot be achieved if the so-called first-species-rule is followed. Many authors act as though they were under the impression that there is a rule or recommendation saying that the first species of a genus determines the type of a genus. This is not true for the International Rules of Botanical Nomenclature. On the contrary, the recommendations of the text of 1935 (Recommendation VI, p. 4) emphasize, especially for the fungi, the necessity of passing the first species by in order to fix the generic names as they are now commonly applied.

(3) The lectotype shall be selected from the species *not* belonging in any outstanding group which has been or may in the future be separated from the bulk of the genus unless the following paragraph applies:

The lectotype shall be selected from a group of species that has been claimed to be a separate genus rather than from a group of species that represents another older or generally accepted genus only when the genus into which the thus selected type species belongs would otherwise remain without a generic name, and provided that the maintaining of the particular generic name in question in an emended sense appears desirable. For instance, it has generally been considered to be desirable to save the Friesian names *Psilocybe* and *Armillaria*. This can only be done by accepting as type species of these genera *Psilocybe semilanceata* and *Armillaria luteovirens* because otherwise they would become synonyms of *Psathyrella* in the case of *Psilocybe* and *Tricholoma* in the case of *Armillaria* and the group around *Psilocybe semilanceata* as well as the genus into which *Armillaria luteovirens* belongs would have to be given new generic names.

(4) The lectotype should be selected from several otherwise suitable species by giving preference to the one which is best known

<sup>4</sup> According to the International Rules, Recommendation VI.

<sup>5</sup> According to the International Rules, Recommendation VI, footnote (1).

or the one which has been studied from all aspects and thus offers a clear picture of the affinities of the type species (and consequently the genus also) in case the definition of the genus should have to be changed.

(5) The lectotype should be selected (unless other factors make this impossible) according to the historical development of the generic concept in every particular case. In *Naucoria*, for instance, the genera *Tubaria*, *Agrocybe*, *Pholiotina*, *Phacomarasmius*, *Alnicola* and *Phacocollybia* (or elements of these genera) have, in this order, been split from *Naucoria*. It is therefore obvious that none of the authors who thus emended the genus *Naucoria* by gradually restricting it to a homogeneous group, considered the part they removed as containing the species "permanently associated" with that name. If these authors have actually emended the old concept of the genus, and if the groups they segregated have been accepted by some independent mycologists, we should not select a lectotype for *Naucoria* that deliberately eliminates one of these segregated genera. The lectotype should be selected from the generic group not yet designated as a separate genus under a new name. However, if, in contradiction to the Rules, the genus has been entirely split up and the original generic name discarded, one of the segregated groups (preferably one of those established by the author who discarded the original name) should be re-established under the original generic name for the whole group. In the case of *Naucoria* this is the group containing *N. centunculus*, *N. carphophila*, *N. effugiens*, etc. The same principle leads to *Hypholoma Candolleianum* as the type species of *Hypholoma* rather than to a species of the *fasciculare*-group, since Karsten first emended the genus *Hypholoma* by removing the latter group, making it the nucleus of his new genus *Naematoloma*.

(6) If, after elimination of such species as are not fit to be proposed as lectotypes according to the above principles, several species remain to be selected from, we gave preference to those most typical (i.e., most closely corresponding to the original diagnosis of the genus or the group on which the genus is based) of the genus and around which mycological tradition has been built, as for example, *Tricholoma equestre*. We give this principle a secondary place in view of Article 18, note, providing that the

above requirements are not necessary conditions under which a species can be chosen as lectotype under the type method. Nevertheless, it may be assumed that species conforming with the above requirements are less likely to be considered atypical in future taxonomic treatments than others, and therefore, our principle (6) will contribute to the aim outlined under (3).

(7) Preference is also given to such species as have been previously suggested though not officially accepted as species *lectotypicae* by other authors (Earle, Murrill, Clements & Shear, Maire, Wakefield and others) or by the senior author in a previous paper, in order not to destroy anything that could be considered as a tradition or the limited beginning of it. Nevertheless, if such a proposal is found to be impractical according to our general views as presented in this paper, it is abandoned.

(8) In accordance with the Rules genera whose type species have been indicated by their author are rigidly based on this particular species, and the type species cannot at present be altered any more than the following list of lectotypes could be altered once it has been accepted by an International Congress dealing with questions of nomenclature. Such genera are therefore omitted from the following list unless the evidence of a type species has been overlooked or ignored by later authors not adhering to the type method or not applying it.

#### LIST OF PROPOSED LECTOTYPES OF THE GENERA OF AGARICS

(Species *lectotypica* *proposita* *Agaricinearum*)

#### I. Ex Fries, *Systema Mycologicum* 1. 1821.

1. AGARICUS L. ex Fr. Syst. Myc. 1: 5. 1821. *A. campestris* L. ex Fries.

Discussion of lectotype:<sup>6</sup> Since *Agaricus* must be maintained as a genus according to Art. 51 of the International Rules it is

<sup>6</sup> The paragraphs *Discussion of lectotype* and *Status of generic name* are not intended to be part of the proposal to be submitted for official acceptance. They are merely an explanation of the reasons motivating some of our proposals and a conclusion showing their consequences. We hope this will facilitate reciprocal understanding and more efficacious discussions between now and the time these *species lectotypicae* are eventually acted upon.



best to follow established usage. Schroeter's emendation of *Agaricus* has never been widely accepted. Since the emendation proposed by Karsten and also by Saccardo has come into general use the world over it is the one we recognize. Consequently a species of the tribus *Psalliota* Fr. is chosen.

Status of generic name: Valid; genus generally accepted by taxonomists.

2. *CANTHARELLUS* *Adans. ex Fr. l.c. p. 316. C. cibarius* Fries.

Discussion of lectotype: Any other choice would exclude *C. cibarius* from the genus in the sense of some modern classifications. This would be contrary to tradition and impractical since a new generic name for *C. cibarius* would be required.

Status of generic name: Valid; genus generally accepted by taxonomists.

3. *SCHIZOPHYLLUM* Fr. *l.c. p. 330. S. commune* Fries.

Status of generic name: Valid; genus generally accepted by taxonomists.

II. *Ex S. F. Gray, Natural Arrangement of British Plants 1. 1821.*

4. *AMANITA* Pers. ex Gray, *l.c. p. 599. A. bulbosa* Schaeff. ex Gray.

Discussion of lectotype: *A. bulbosa* is a synonym of *Agaricus phalloides* Fries, Syst. Myc. 1: 13. 1821. Thus the name clearly indicates a homogeneous group of species with amyloid spores and membranous volvas. These belong in the subgenus *Euamanita* of recent classifications. Our selection of *A. bulbosa* is logical since it preserves the tradition associated with the name and is in line with modern usage. The other species included by Gray are either not so clearly in a distinct group (*A. citrina*) or they belong to other groups of *Amanita* with the volva more poorly developed or even absent.

Status of generic name: Valid; genus generally accepted by taxonomists.

5. VAGINATA Nees v. Esenb. ex Gray, *l.c.* p. 601. *V. livida* (Pers.) ex Gray.

Discussion of lectotype: *Amanita livida* Pers. is the same as *Agaricus vaginatus* Bull. according to Gray himself. This is *Amanita vaginata* or *Amanitopsis vaginata* of modern authors. Gray included three species in his assemblage, one of which is a *Volvaria* or *Volvariopsis*. Since the other two species are white spored it is logical to make the selection from them, particularly since this concept already exists in the literature. Murrill used Gray's name in the North American Flora and designated *V. livida* as the type.

Status of generic name: Valid; genus accepted by some taxonomists.

6. LEPIOTA (Pers.) ex Gray, *l.c.* p. 601. *L. colubrina* (Pers.) ex Gray.

Discussion of lectotype: It should be selected from among the species included by Gray, but not from those which have been placed in other genera by recent authors. This excludes *L. procera*, *L. granulosa*, *L. squarrosa*, *L. aurca*, *L. polymyces*, *L. caudicina* and *L. helvola*. The only acceptable species is *L. colubrina* which is considered a synonym of *L. clypeolaria* and is therefore consistent with the senior author's earlier proposal.

Status of generic name: Valid; genus generally accepted by taxonomists.

7. GYMNOPUS (Pers.) ex Gray, *l.c.* p. 604. *G. purus* (Pers. ex Fr.) Gray.

Discussion of lectotype: Since this choice does not invalidate well established names such as *Collybia*, *Hygrophorus*, *Tricholoma*, etc. and yet connects the name to a group of species which is rather distinct and which eventually might be recognized as a genus by some workers, it appears to be the logical choice. At the present time it would be considered a synonym of *Mycena* by those who maintain the genus either in the concept of Kühner or Singer.

Status of generic name: Valid; genus at present considered a synonym of *Mycena*.

8. *OMPHALIA* (Pers.) ex Gray, *l.c.* p. 611. *O. adusta* (Pers. ex Fr.) Gray.

Discussion of lectotype: *O. adusta* appears to be the only choice not endangering such well established names as *Collybia*, *Clitocybe*, *Laccaria*, *Paxillus*, etc. There is no species in Gray's assemblage or for that matter Persoon's either, that belongs in *Omphalia* (Fr.) Quél. 1872. On the basis of our selection, *Omphalia* becomes a synonym of *Russula*. *O. adusta* as cited by Gray is a combination of *Russula nigricans* (Bull. ex Fr.) Fr. and *R. adusta* (Pers. ex Fr.) Fr. sensu str. Fr. and probably *R. densifolia* (Secr.) Gill. All these belong to the section *Compactae* of *Russula*. *Omphalia* (Fr.) Quél. must be replaced by *Omphalina* Quélet.

Status of generic name: Valid; but type species generally considered congeneric with type of *Russula*. The legal status of both names is identical but we prefer *Russula* according to general usage.

9. *PLEUROPUS* (Pers.) ex Gray, *l.c.* p. 615. *P. fornicatus* Pers. ex Gray.

Discussion of lectotype: No matter which species in Gray's assemblage is selected one of the well established genera (*Clitopilus*, *Lyophyllum*, *Rhodotus* or *Panus*) would be invalidated. *Panus* is the only one that apparently is represented by more than one species, and is the only one of the four previously proposed for conservation for other reasons (see p. 292). Therefore we have selected *P. fornicatus* as lectotype. This makes *Panus* a synonym of *Pleuropus* unless it is conserved by the Congress.

Status of generic name: Valid, unless rejected in favor of *Panus* which we propose for conservation.

10. *CREPIDOPUS* Nees v. Esenh. ex Gray, *l.c.* p. 616. *C. ostreatus* (Jacq. ex Fr.) Gray.

Discussion of lectotype: A selection of any one of the five species included by Gray would result in the substitution of *Crepidopus* for one of the well known genera. Consequently we are merely following Murrill who selected *Agaricus ostreatus* as the type.

Status of generic name: Valid, unless rejected in favor of *Pleurotus*, which we propose for conservation.

11. APUS Nees v. Esenb. ex Gray, *l.c.* p. 617. *A. alneus* L.  
- ex Gray.

Discussion of lectotype: *A. alneus* is a synonym of *Schizophyllum commune*.

Status of generic name: Synonym of *Schizophyllum* (same type).

12. RESUPINATUS Nees v. Esenb. ex Gray, *l.c.* p. 617. *R. applicatus* (Batsch ex Fr.) Gray.

Discussion of lectotype: This is *Pleurotus applicatus* or *Scytinotopsis applicata* of present nomenclature.

Status of generic name: Valid; genus accepted by some modern authors (under names which are later synonyms).

13. RUSSULA Pers. ex Gray, *l.c.* p. 618. *R. lutea* (Huds. ex Fr.) Gray.

Status of generic name: Valid; genus accepted generally by taxonomists.

14. MYCENA (Pers.) ex Gray, *l.c.* p. 619. *M. galericulata* (Scop. ex Fr.) Gray.

Discussion of lectotype: The largest element in Gray's assemblage is clearly *Mycena* in the Friesian sense. It is therefore desirable to choose one of the species belonging to the genus in its most restricted sense and at the same time the one most common and completely known. This is *M. galericulata*. It is also the species already accepted in the literature as the type species.

15. MICROMPHALE (Nees v. Esenb.) ex Gray, *l.c.* p. 621. *M. venosum* Pers. ex Gray.

Discussion of lectotype: *Micromphale venosum* is a synonym of *Marasmius foetidus* or *Heliomyces foetidus* of present taxonomists. This name would therefore replace either *Marasmius* Fr. or *Heliomyces* sensu Singer, 1936, depending on whether the *M. foetidus*-group is separated from the bulk of *Marasmius* or left within it. *Micromphale* Gray would be extremely unwelcome as a name for

all species of *Marasmius* (which it would replace if some other species were chosen), but it would be welcome as a substitute for *Heliomyces* sensu Singer since the latter would have to be re-named anyway because the group is generically different from the type species of *Heliomyces* in the original sense. Two species in *Micromphale* Gray belong to *Heliomyces* sensu Singer (*Marasmius*, section *Gloeonemi* Kühner), whereas two others belong in *Marasmius* sensu str. The other species in Gray's assemblage consist of still smaller elements not very closely related to *Marasmius*. If *M. venosum* is chosen as lectotype a new generic name for *Heliomyces* sensu Singer becomes unnecessary. The name *Micromphale* will not interfere by virtue of its priority with established generic names unless *Marasmius* is understood in the broad sense. For a discussion of this situation and our recommendation see p. 295.

Status of generic name: Valid. In the sense of *Heliomyces* Singer 1936 and Maire 1937 it is an acceptable genus. As a substitute for *Marasmius* Fries it is not wanted. We propose that *Marasmius* Fries be conserved against it only when *Marasmius* is used in the broad Friesian concept.

16. LACTARIUS D. C. ex Gray, l.c. p. 623. *L. deliciosus* (L. ex Fr.) Gray.

Discussion of lectotype: We decided in favor of the best known and most widely used species, see principle (6), p. 246.

Status of generic name: Valid; genus generally accepted by taxonomists.

17. PRATELLA (Pers.) ex Gray, l.c. p. 626. *P. campestris* (L. ex Fr.) Gray.

Discussion of lectotype: This is the most widely known species of the genus and with certainty referable to a generic group that has alternately been called *Psalliota*, *Pratella* and *Agaricus*. We recommend the use of the name *Agaricus*, see genus 1.

Status of generic name: A synonym of *Agaricus* L. ex Fr. (same type).

18. *CORTINARIA* (Pers.) ex Gray, *l.c.* p. 627. *C. violacea* (Bolt. ex Fr.) Gray.

Discussion of lectotype: The lectotype we propose belongs to the largest element of *Cortinaria* Gray and is consistent with the senior author's and other writers' previous proposals.

Status of generic name: Valid, but we propose *Cortinarius* Fr. for conservation.

19. *PRUNULUS* Ces. ex Gray, *l.c.* p. 630. *P. extintorius* Bolt. ex Gray.

Discussion of lectotype: Apparently *P. extintorius* is the only possible binomial in Gray's assemblage which if selected would not endanger or replace established generic names.

Status of generic name: Valid, but type species generally considered congeneric with type of *Coprinus* (Pers.) ex Gray. The latter and *Prunulus* therefore have the same nomenclatorial status, but we prefer *Coprinus* according to general usage.

20. *COPRINUS* (Pers.) ex Gray, *l.c.* p. 632. *C. comatus* (Pers. ex Fr.) Gray.

Discussion of lectotype: *C. comatus* is undoubtedly the most widely used and best known species and is quite in accordance with the generic description.

Status of generic name: Valid; genus generally accepted by taxonomists. We prefer it to *Prunulus*.

21. *ASTEROPHORA* Ditm. ex Gray, *l.c.* p. 635. *A. lycoperdoides* Bull. ex Gray.

Status of generic name: Valid. In our estimation it should be accepted in preference to *Nyctalis* over which it has priority.

22. *MERULIUS* Gray, *l.c.* p. 636. *M. aurantiacus* (Wulf. ex Fr.) Gray.

Status of generic name: A later homonym of *Merulius* Fr. 1821.

23. *CORNIOLA* Gray, *l.c.* p. 637. *C. lobata* (Pers. ex Fr.) Gray.

Status of generic name: A later homonym of *Corniola* Adans. 1763.

24. GOMPHUS Gray, *l.c.* p. 638. *G. clavatus* (Pers. ex Fr.) Gray.

Status of generic name: Valid; genus accepted by some modern taxonomists (Maire, Singer, Heim, etc.), sometimes under names which are later synonyms, such as *Neurophyllum*. By some authors considered a synonym of *Cantharellus*.

### III. Ex Fries, *Stirpes Agri Femsionensis* III. 1825.

25. GALORRHEUS Fr. *l.c.* p. 56. *G. deliciosus* (L. ex Fr.) Fr.  
Status of generic name: Synonym of *Lactarius* (same type).

26. LENTINUS Fr. *l.c.* p. 57. *L. lepideus* Fr.

Discussion of lectotype: Of the two species mentioned here we selected *L. lepideus* for historic reasons, see principle (5), p. 246.

Status of generic name: Valid; genus generally accepted by taxonomists.

27. NYCTALIS Fr. *l.c.* p. 58. *N. parasiticus* (Bull. ex Fr.) Fr.

Status of generic name: Type species generally considered to be congeneric with the type species of *Asterophora* Ditm. ex Gray. The latter has priority.

### IV. Ex Fries, *Systema Orbis Vegetabilis*. 1825.

28. XEROTES Fr. *l.c.* p. 78. Type not indicated, no species mentioned.

Status of generic name: A hyponym. The genus is too poorly characterized to be linked with anything now known and no type is mentioned; also a homonym of *Xerotes* R. Br. (1810).

### V. Ex Fries, *Elenchus Fungorum*. 1828.

29. XEROTUS Fr. *l.c.* p. 48. *Xerotus afer* Fr.

Status of generic name: Valid.

### VI. Reichenbach, *Conspectus Regni Vegetabilis*. 1828.

30. XEROTINUS Reichenb. *l.c.* p. 14.

Status of generic name: Same as for *Xerotes*.

**VII. Ex Wallroth, Flora Cryptogamica Germaniae 2. 1833.**

31. RHIPIDIUM Wallr. *l.c.* p. 742. *R. stypticum* Wallr.

Discussion of lectotype: *R. stypticum* Wallr. is a synonym of *Schizophyllum commune* (in contrast with the usual erroneous citation of it as a synonym of *Panellus stypticus*).

Status of generic name: A homonym of several older genera in addition to being a synonym of *Schizophyllum* (same type).

**VIII. Ex Fries, Genera Hymenomycetum. 1836; Epicrisis 1836-38 (genera mentioned here published in 1838).**

- a). Genera Hymen. 1836.

32. CORTINARIUS Fr. *l.c.* p. 7. *C. violaceus* (L. ex Fr.) Fr.

Status of generic name: Originally (1836) a hyponym, but later validated by Fries (1838). However, *Cortinaria* Gray is based on the same type and has priority (1821 as against 1838). *Cortinaria* Gray is not a variant spelling according to the Rules. If the masculine gender (spelling *Cortinarius*), which has been used since 1838 with but very few minor exceptions, is to be retained, it must be accepted by the Congress. We propose *Cortinarius* for conservation.

33. GOMPHIDIUS Fr. *l.c.* p. 8. *G. glutinosus* (Schaeff. ex Fr.) Fr.

Status of generic name: Valid; genus generally accepted by taxonomists.

34. HYGROPHORUS Fr. *l.c.* p. 8. *H. eburneus* (Bull. ex Fr.) Fr.

Status of generic name: Valid; genus generally accepted by taxonomists in either a broad or restricted sense.

35. MARASMIUS Fr. *l.c.* p. 9. *Marasmius rotula* (L. ex Fr.) Fr.

Discussion of lectotype: In our opinion, none of the species subsequently separated from *Marasmius* when the latter was restricted by the exclusion of various groups should be proposed as lectotype. Therefore *Marasmius*, sect. *Rotulae* Kühn. (*Marasmius*



sensu Earle), is the one section from which a lectotype should be chosen. We have proposed the best known and most widely distributed species of that section. Since in our opinion *Marasmius rotula* and *M. foetidus* are not congeneric, there is no need to conserve *Marasmius* against *Micromphale*. However, others may not agree and for them it is imperative to propose *Marasmius* for conservation (see discussion, p. 295).

Status of generic name: Valid; genus generally accepted by taxonomists in either a broad or restricted sense. The type species is considered by some to be generically identical with the type species of *Micromphale* and in this concept *Marasmius* is in need of conservation. We recommend that it be so conserved.

36. TROGIA Fr. *l.c.* p. 10. *Cantharellus apilorutis* Mont.

Discussion of lectotype: This species is indicated as the type by Fries himself, and we list it here only because this fact has been overlooked, and some authors treat *Trogia* in a manner which suggests *T. crispa* as the type species.

Status of generic name: Valid; genus generally accepted by taxonomists.

37. LENZITES Fr. *l.c.* p. 10. *Lenzites betulina* (L. ex Fr.) Fr.

Discussion of lectotype: The selection of the type has been made in accordance with the established usage by investigators of the polypores, thus excluding the representatives of what was later transferred to *Glocophyllum*.

Status of generic name: Valid, and genus generally accepted by taxonomists but now almost unanimously excluded from the Agaricineae.

38. PLUTEUS Fr. *l.c.* p. 6. *Agaricus pluteus* Batsch ex Fr.  
syn. excl.

Discussion of lectotype: Fries' remarks, *l.c.*, admit as candidates for the lectotype several species given in *Systema Mycologicum*. It appears obvious that *A. pluteus* must have been the species most intimately linked with his idea of the genus *Pluteus*, hence the name. Therefore, there was no other reasonable choice. Since

*A. pluteus* is a synonym of what we now correctly<sup>7</sup> call *Pluteus cervinus* (Schaeff. ex Fr.) Quélet, we may add that our lectotype is also the most widely known and distributed species of the genus, and, in addition, the only one that is to some extent used as an edible mushroom. We must, however, add "synonymis exclusis" when citing *A. pluteus* since in 1821 Fries apparently still confused this species with two belonging in *Entoloma* (*Rhodophyllus* of modern classifications). These were *A. lividus* and *A. clypeatus*. Fries corrected himself later in this regard, and it is obvious that these synonyms were indicated by mistake.

Status of generic name: Valid; genus generally accepted by taxonomists.

39. PAXILLUS Fr. *l.c.* p. 8. *P. involutus* (Batsch ex Fr.) Fr.

Discussion of lectotype: Fries indicates *P. involutus* as the type.

Status of generic name: Valid, unless *Ruthea* Opat. has a slight priority over it. *Paxillus* is generally accepted as valid by taxonomists and we have proposed it for conservation.

b). *Epicrisis* 1838.

40. PANUS Fr. *Epicrisis*, p. 396. *P. conchatus* (Bull. ex Fr.) Fr.

Discussion of lectotype: It is necessary to select one of the species not transferred to *Panellus* by Karsten and his followers, and not transferred to *Lentinus* by any who admit the genus *Panus*. In this case only *Panus torulosus* and *P. conchatus* are available as possible lectotypes, and we selected the latter since the two are identical and *L. conchatus* appears to be the preferred name.

Status of generic name: Synonym of *Pleuropus* (Pers.) ex Gray but proposed for conservation by Maire.

41. *Bolbitius* Fr. *l.c.* p. 253. 1838. *B. fragilis* (L. ex Fr.) Fr.

Status of generic name: Valid; genus generally accepted by taxonomists.

<sup>7</sup> See Art. 68.3 of International Rules. *A. pluteus* cannot be legally transferred to the genus *Pluteus* without a change in the species epithet. This change was proposed by Fries when he took up a name of Schaeffer.

**IX. Ex Lévillé, Annales des Sciences Naturelles III. 2. 1844.**

42. *Heliomyces* Lév. *l.c.* p. 177. *H. elegans* Lév.

Status of generic name: Valid, but in our opinion the type and all other species originally included are congeneric with the type species of *Marasmius*. As for *Heliomyces* sensu Sing. 1936 and Maire 1937, see p. 295.

**X. Ex Rabenhorst, Deutschlands Kryptogamen-Flora 1. 1844.**

43. *Rhymoxis* Rab. *l.c.* p. 572. *R. involutus* (Batsch ex Fr.) Rab.

Status of generic name: Synonym of *Paxillus* (same type). The genus *Rhymoxis* Pers. (not *Rhymovis* which was a printer's error) was proposed by Persoon conditionally, i.e. it was not validly published. Rabenhorst, though misspelling it, tried to validate it. However, in the meantime other genera had been published for the same species, i.e. *Ruthea* and *Paxillus*.

**XI. Ex Montagne, Cryptogamia Guyanensis, Annales des Sciences Naturelles IV. 1. 1854.**

44. *HIATULA* (Fr.) Mont. *l.c.* p. 107. *H. Benzonii* (Fr.) Mont.

Status of generic name: Valid; genus accepted by many taxonomists. Some authors recognize *Leptomyces* Mont. rather than *Hiatula* (Fr.) Mont. but it should be remembered that Montagne used *Hiatula* as a genus two years before he erected his own genus, *Leptomyces*. His first mention of it (*l.c.* p. 107) must refer to manuscript notes, but he also mentions *H. Benzonii* (*l.c.*).

**XII. Ex Montagne, Sylloge Cryptogamarum. . . . 1856.**

45. *LEPTOMYCES* Mont. *l.c.* p. 128. *L. lignifraga* (Mont.) Mont.

Status of generic name: Valid, but Montagne himself suspected that it was the same as *Hiatula*, and it is not accepted by any author thus far as different. We consider it a synonym of *Hiatula*.

**XIII. Ex Peck, Annual Report N. Y. State Museum 24. 1872.****46. PLICATURA Peck, l.c. p. 75. *P. Alni* Peck.**

Status of generic name: Valid; the genus belongs in the *Meruliaceae*. It is accepted by some authors in the sense of *Trogia* auct. non Fries, but considered as a synonym of *Merulius* by others. If *P. Alni* Peck is considered a true *Merulius*, and the group around "*Trogia*" *crispa* considered to be generically different from *Merulius*, the genus *Pleurotopsis* (Henn.) Earle is still available as a generic name for *P. crispa* and *P. spodoleuca*.

**XIV. Ex Quélet, Champignons du Jura et des Vosges. 1872-73.****47. ARMILLARIA (Fr.) Quél. l.c. p. 74. *Agaricus luteovirens* A. & S. ex Fries, Monogr.**

Discussion of lectotype: see our principle (3), p. 245.

Status of generic name: Valid; genus generally accepted but under varying concepts depending on the author.

**48. TRICHOLOMA (Fr.) Quél. l.c. p. 76. *T. equestre* (L. ex Fr.) Quél.**

Discussion of lectotype: According to our principle (3) we have excluded from consideration any species which belongs in one of the groups which have since been segregated from *Tricholoma*, i.e. *Melanoleuca*, *Leucopaxillus*, *Lyophyllum*, *Cortinellus*, *Rhodopaxillus*, *Tricholomopsis*, and *Calocybe*. In order to be consistent with Fries' concept of *Tricholoma* we must select a species from the section *Tricholomata Genuina* Fr. (Syst. Myc.). Undoubtedly the best known species is *Agaricus flavovirens*, a synonym of what Fries later (in Monographia Suec.) called *Agaricus equestris*, and Quélet *Tricholoma equestris*. This choice of lectotype is in accord with the senior author's former (1936) proposal. When Fries transferred this species to the section *Limacina* (1836), he abandoned at the same time his old section *Genuina*.

Status of generic name: A homonym of *Tricholoma* Benth. (1820), but *Tricholoma* (Fr.) Quél. has been proposed for conservation.

49. CLITOCYBE (Fr.) Quél. *l.c.* p. 85. *C. infundibuliformis* (Schaeff. ex Fr.) Quél.

Discussion of lectotype: We chose as lectotype one of the species most typical of the genus. *C. nebularis* and *C. odora* do not have truly white spore deposits and *C. laccata* was transferred to *Laccaria* long ago. *C. infundibuliformis*, in addition, is widely distributed and well known.

Status of generic name: Valid; genus generally accepted by taxonomists.

50. COLLYBIA (Fr.) Quél. *l.c.* p. 92. *C. dryophila* (Bull. ex Fr.) Quél.

Discussion of lectotype: Many species of *Collybia* do not have pure white spores. All of these, of course, should be excluded from consideration. This eliminates *C. butyracea* and *C. maculata*. We have selected the best known and most widely distributed species that answers perfectly to the generic description. It is important that no species used as the type of recently segregated genera be considered. This eliminates *C. esculenta*, *C. myosura*, *C. laccrata*, *C. longipes*, *C. radicata*, and *C. velutipes*.

Status of generic name: Valid; genus generally accepted by taxonomists.

51. OMPHALIA (Fr.) Quél. *l.c.* p. 99. *O. umbellifera* (L. ex Fr.) Quél.

Discussion of lectotype: (see under *Omphalina* Quél.).

Status of generic name: A homonym of *Omphalia* (Pers.) ex Gray.

52. PLEUROTUS (Fr.) Quél. *l.c.* p. 62.<sup>8</sup> *P. ostreatus* (Jacq. ex Fr.) Quél.

Discussion of lectotype: If all species transferred to or belonging to such modern genera as *Geopetalum* (*Acanthocystis*), *Pleurotellus* (*Calathinus*), *Resupinatus* (*Scytinotopsis*), *Rhodotus*, *Phylotopsis*, *Lyophyllum*, *Tricholomopsis*, etc. are excluded from consideration, it appears obvious that the lectotype has to be selected from the *P. dryinus*-group (as is suggested by Murrill in North

<sup>8</sup> Spelled *Pleurote* on p. 111.

American Flora), or from the *P. ostreatus*-group. Historically both solutions would be equally correct. We decided in favor of *P. ostreatus* because of its importance in commerce (edible mushroom, imported to China from various Asiatic territories, and an ever-present element in almost all the floras of the world). Also, its complicated sexuality as studied by Vandendries makes it an outstanding type among the Basidiomycetes and consequently an important subject for teaching. There is only one fact that might be brought up against its selection as lectotype, namely its slightly (drab) colored spores. However, there is no well known species among the Pleuroti of the *ostreatus*-group which has unquestionably pure white spores in a good deposit on white paper. Since the color of the deposit is not always evident at the moment one removes the cap from the paper, and since it is often almost too slight to notice, it does not seem wise to allow this consideration to carry more weight than all the others combined.

Status of generic name: Synonym of *Crepidopus* Nees v. Esenb. ex Gray but proposed for conservation.

53. VOLVARIA (Fr.) Quél. *l.c.* p. 114. *V. speciosa* (Bull. ex Fr.) Quél.

Status of generic name: This is a homonym of *Volvaria* DC (1805), but has been proposed for conservation by R. Maire.

54. ENTOLOMA (Fr.) Quél. *l.c.* p. 116. *E. lividum* (Bull. ex Fr.) Quél.

Status of generic name: Valid; however, for a generic name involving species of genera 54, 56, 57 and 58 the name *Rhodophyllus* Quél. is proposed for conservation, see p. 295.

55. CLITOPILUS (Fr.) Quél. *l.c.* p. 120. *C. prunulus* (Scop. ex Fr.) Quél.

Status of generic name: Valid; genus accepted generally by taxonomists (sometimes under the name *Hexajuga* Fayod).

56. LEPTONIA (Fr.) Quél. *l.c.* p. 121. *L. anatina* (Lasch) Quél.

Status of generic name: Valid; genus still recognized by some taxonomists.

57. *NOLANEA* (Fr.) Quél. *l.c.* p. 122. *N. pascua* (L. ex Fr.) Quél.

Status of generic name: Valid; genus still recognized by some taxonomists.

58. *ECCILIA* (Fr.) Quél. *l.c.* p. 123. *Agaricus* (*Eccilia*) *parkensis* Fr. in *Monographia*.

Status of generic name: Valid; genus still recognized by some taxonomists.

59. *PHOLIOTA* (Fr.) Quél. *l.c.* p. 124. *P. squarrosa* (Muell. ex Fr.) Quél.

Discussion of lectotype: *Pholiota* sensu Quélet contained a number of diverse groups of species many of which have since been recognized as genera. In our opinion the group to which the name *Pholiota* is inseparably attached both by usage the world over on the part of specialists and the general public is the *P. squarrosa* group. Many of these fungi are important to foresters because of the rots they cause, and many are commonly collected by people to be used as food. There is another reason for selecting the most strongly squarrose species as the type: The name applied by Fries suggests, as he himself has pointed out, the Greek word "pholis," i.e., scale. Thus the species placed in *Pholiota* logically should be scaly fungi. Also, the color of the spores is given as "ferruginea raro fulvo-ferruginea." This excludes such species as those belonging in *Agrocybe* and also those belonging in *Gymnopilus* (*Fulvidula*) as well as *Phacolepiota*, *Rozites* and *Pholiotina*. A similar color distinction excludes the same groups of species in Quélet *l.c.*

Status of generic name: Valid; genus generally accepted by taxonomists. Overholts cites 1825 as the year of publication of Paulet's genus *Hypodendrum*, which he used in the North American Flora but not in his other publications. This should give *Hypodendrum* a solid priority over *Pholiota*. However, we know nothing of a generic description given by Paulet at the time cited by Overholts. Paulet called all agarics *Fungus* in his (pre-Friesian) text, and does not (though Murrill says he does) even

mention the genus *Hypodendrum*. When he published his plates, and these appeared over a long period of time—some not appearing until after his death—he must have changed his mind about the genera to be applied to his agarics because the common names in the text volumes are accompanied by Latin binomials or what appear to be binomials. But no word of Paulet's was found which would confirm that *Hypodendrum* or other generic names were actually meant to be new genera. Nor were these validated in Lévillé's edition of Paulet's plates. Lévillé applied the generic names of his time (mostly *Agaricus*) and gave Paulet's names as synonyms, a form of publication that is not valid according to the International Rules. In view of the confused situation in regard to the early use of the name *Hypodendrum*, and the fact that Overholts himself never used it in other publications on the genus, there is no advantage to be gained by establishing it, and the confusion which would result if it were established would be serious.

60. *HEBELOMA* (Fr.) Quélet. *l.c.* p. 128. *H. fastibile* (Fr.) Quélet.

Status of generic name: Valid; genus generally accepted by taxonomists.

61. *Flammula* (Fr.) Quélet. *l.c.* p. 129. *F. flavida* (Schaeff. ex Fr.) Quélet.

Discussion of lectotype: We exclude from consideration species from sections not typical according to the diagnoses given by Fries and Quélet (the *Heterogenei* and *Sapinei*). These have since been segregated as genera. This leaves the species *F. gummosa*, *F. flavida* and *F. azyza* in Quélet and a few more in Fries' *Monographia*. Earle based his genus *Visculus* on the section *Lubrici* but his intention was to give this group which he considered as *Flammula* proper a nomen novum. According to our principle (7), p. 247 we prefer *F. flavida*. This is the species indicated by Clements & Shear and by Singer and has also been recommended by the Nomenclature Commission of the British Mycological Society as one of two alternatives called "most suitable."

Status of generic name: A homonym of *Flammula* D. C. (1818), but proposed for conservation by R. Maire. Though it would be



most desirable to be able to conserve *Flammula* (Fr.) Quél. it may well be that intercommisisonal difficulties will arise over this question. In the end, it may be that a name for *Flammula* (Fr.) Quél. non D. C. is not so badly needed after all. We believe the generic differences between *Pholiota* and *Flammula* in the sense of modern authors are too small to justify the separation of these genera.

62. NAUCORIA (Fr.) Quél. *l.c.* p. 131. *Agaricus* (*Naucoria*) *centunculus* Fr.

Discussion of lectotype: The lectotype was chosen from Fries' Monographia in accordance with principle (5), p. 246.

Status of generic name: Valid; genus generally accepted by taxonomists.

63. GALERA (Fr.) Quél. *l.c.* p. 135. *G. hypnorum* (Batsch ex Fr.) Quél.

Discussion of lectotype: We do not agree with the statements and recommendations made in the Transactions of the British Mycological Society 23: 228-229, nor do we support Maire's proposal to conserve *Galera* (see Discussion of Nomina generica conservanda proposita, p. 291). Since Fayod first emended *Galera* (see our principle (5), p. 246), the type species cannot be in the group which he designated a new genus. Among the species now called *Galerina* and still frequently referred to as section *Bryogenae* of *Galera*, the most widely distributed and common species is *G. hypnorum*.

Status of generic name: A homonym of *Galera* Blume (1825).

64. CREPIDOTUS (Fr.) Quél. *l.c.* p. 138. *C. mollis* (Schaeff. ex Fr.) Quél.

Status of generic name: Valid; genus generally accepted by taxonomists.

65. PSALLIOTA (Fr.) Quél. *l.c.* p. 139. *P. campestris* (L. ex Fr.) Quél.

Status of generic name: A synonym of *Agaricus* L. ex Fr. em. Karsten (same type).

66. STROPHARIA (Fr.) Quél. *l.c.* p. 141. *S. aeruginosa* (Curt. ex. Fr.) Quél.

Discussion of lectotype: The genus *Stropharia* is heterogeneous and this makes it important not to select a species belonging in *Psathyrella* or to Romagnesi's proposed new group *Stercophila*. Some species should not be selected because they are too close to *Naematoloma* Karsten. *S. aeruginosa* is the most easily recognized and commonest species, and one that has been studied from various points of view.

Status of generic name: Valid; genus generally accepted by taxonomists.

67. HYPHOLOMA (Fr.) Quél. *l.c.* p. 143. *H. Candolleum* (Fr.) Quél.

Discussion of lectotype: If species belonging in groups which have been separated generically from *Hypholoma* are excluded there are only a few of the section *Appendiculati* available. The only one of these well enough known to be fit for selection is *H. Candolleum*.

Status of generic name: Valid; genus accepted by some authors. Others consider the type congeneric with *Psathyrella*.

68. PSILOCYBE (Fr.) Quél. *l.c.* p. 147. *Agaricus semilanceatus* Fr. Monogr.

Discussion of lectotype: See our principle (3), p. 245.

Status of generic name: Valid; genus generally accepted by taxonomists though variously limited.

69. PSATHYRA (Fr.) Quél. *l.c.* p. 148. *P. spadiceogrisea* (Schaeff. ex Fr.) Quél.

Status of generic name: A homonym of *Psathyra* Spreng. (1818).

70. PANAEOLUS (Fr.) Quél. *l.c.* p. 151. *P. campanulatus* (L. ex Fr.) Quél.

Status of generic name: Valid; genus generally accepted by taxonomists.

71. *PSATHYRELLA* (Fr.) Quél. *l.c.* p. 152. *P. gracilis* (Fr.) Quél.

Status of generic name: Valid; genus generally accepted by taxonomists. Those who believe *Hypholoma* to be congeneric with *Psathyrella* will notice that the nomenclatorial status of *Hypholoma* and *Psathyrella* is the same, i.e., they were published validly in the same book and at the same date. However, in order to keep nomenclature as stable as possible, we strongly recommend *Psathyrella* in preference to *Hypholoma* because (1) the name *Hypholoma* has been used in two distinct senses and would thus be likely to cause confusion; (2) the name *Psathyrella* has been preferred by all modern taxonomists except Romagnesi (who does not use *Hypholoma* either); (3) *Hypholoma* has never been used in the sense of *Psathyrella* sensu Kühner or *Drosophila* sensu Romagnesi.

72. *INOCYBE* (Fr.) Quél. *l.c.* p. 178. *I. geophylla* (Sow. ex Fr.) Quél.

Discussion of lectotype: We chose a species with smooth spores and typical "Inocybe"-odor and "Inocybe"-cystidia. The species with nodulose or angular spores have—though in our opinion wrongly—been separated generically from *Inocybe* by several authors.

Status of generic name: Valid; genus generally accepted by taxonomists.

**XV. Ex Gillet, Champignons de France, texte 1874-78 (Nos. 73-78 were published in 1876).**

73. *LEPISTA* (Fr. p.p.) Gillet, *l.c.* p. 195. *L. Alexandri* Gill. (see No. 81 also).

Discussion of lectotype: It is necessary to choose between *L. Alexandri* and *L. truncata* in the selection of a lectotype. The selection of the latter would lead to numerous complications. *L. truncata* is now placed in *Rhodopaxillus* by many taxonomists and others still consider it a *Tricholoma*. We believe it would be unfortunate to replace *Rhodopaxillus* with *Lepista*, a name already used in so many different concepts that it may properly be designated a *nomen ambiguum*. Since the name *Tricholoma* is

not yet conserved it might happen, if favorable action is not taken, that *Lepista* (if *L. truncata* is selected as lectotype) would have to be substituted for it by those who retain a broad concept of *Tricholoma*. This would be very unfortunate. On the other hand, *L. Alexandri*, as the species is now generally delimited, is considered to be a *Clitocybe* and *Clitocybe* has definite priority over *Lepista*. Consequently other generic names would not be endangered if it is selected.

It may be asked whether it is correct to select the type species from Gillet instead of from Fries. In the case of Quélet we insisted that the species had to be one included in the two Friesian works cited by Quélet. In the case of Gillet, however, we cannot find any indication of whether or not the genus is understood in the sense of any one of Fries' works, even though Fries is mentioned as the authority. It is obvious that Gillet had more knowledge of *L. Alexandri* than of *L. truncata*, and it appears to us that he included more characters of the former than of the latter in the generic diagnosis. It is also worthy of note that in *Hymenomycetes Europaei* Fries included *L. Alexandri* in the genus *Paxillus*, tribe *Lepista*. If, for some reason, it be insisted that the lectotype be designated a species that is found in *Epicrisis*, we would propose *Paxillus extenuatus*. In Ricken's sense, and we agree with Ricken, this is the same as *L. Alexandri*. Because there is some disagreement over the concept of *P. extenuatus* it could then be regarded as a dubious species and *Lepista* discarded as a *nomen ambiguum*.

Status of generic name: With *L. Alexandri* as lectotype it is valid but a synonym of *Clitocybe*.

74. ANNULARIA (Schulz.) Gill. *l.c.* p. 389. *A. Fenzlii* (Schulz.) Gill.

Status of generic name: A homonym of *Annularia* Sternb. (1823).

75. CLAUDOPUS (Fr.) Gill. *l.c.* p. 426. *C. byssisedus* (Pers. ex Fr.) Gill.

Discussion of lectotype: It was necessary to exclude *C. variabilis* from consideration because it was segregated by Patouillard

under a different generic name. Ricken, 1913, was the first to emend the genus *Claudopus* by excluding all species with non-angular spores. This makes it doubly necessary to confine ourselves to species with angular spores when considering a lectotype. Of these *C. byssisedus* is certainly the best known and most widely distributed representative.

76. LOCELLINA Gill. *l.c.* p. 428. *L. Alexandri* Gillet.

Status of generic name: Valid; but the type species is dubious.

77. PLUTEOLUS (Fr.) Gill. *l.c.* p. 549. *P. reticulatus* (Fr.) Gill.

Status of generic name: Valid; genus accepted by some taxonomists.

78. TUBARIA (W. G. Smith) Gill. *l.c.* p. 537. *T. furfuracea* (Fr.) Gill.

Discussion of lectotype: It is important not to select any species recently transferred to other genera such as *Galerina* (*Galerina*) or *Decomica*. The best known, the most common, and the one already proposed by other investigators is *T. furfuracea*.

Status of generic name: Valid; genus generally accepted by taxonomists.

# **XVI. Ex Roze, Bulletin de la Société Botanique de France. 1876.**

79. AMANITOPSIS Roze, *l.c.* p. 51. *A. vaginata* (Bull. ex Fr.) Quél.

Discussion of lectotype: The author of the genus refers to the section *Amanitae Vaginatae*, a name which implies *A. vaginata* as the type species.

Status of generic name: A synonym of *Vaginata* Nees v. Esenb. ex Gray (same type).

80. CORTINELLUS Roze, *l.c.* p. 51. *Agaricus* (*Tricholoma*) *vaccinus* Fr.

Discussion of lectotype: The type species was indicated by Roze himself and we include the genus here only because that type has been disregarded in later emendations.

Status of generic name: Valid; but genus not generally recognized in the above sense. With *A. vaccinus* as lectotype most taxonomists would consider the genus a synonym of *Tricholoma*.

81. *LEPISTA* (Fr.) Roze, *l.c.* p. 51. *L. gilva* (Pers. ex Fr.) Roze.

Discussion of lectotype: The priority of the raised status of *Lepista* (Fr.) is very difficult to establish. *Lepista* (Fr.) Gillet and *Lepista* (Fr.) Roze must have both been published in 1876. In case Roze has priority, the status of the genus would be nomenclatorially valid but congeneric with *Clitocybe* though associated with a different group of species in that genus than *Lepista* (Fr.) Gillet. The same alternate solution proposed for *Lepista* (Fr.) Gillet could also be applied here.

Status of generic name: A synonym of *Clitocybe*.

**XVII. Ex Karsten, Bidr. Finl. Nat. Folk 32: 1-571 (Hattsvampar). 1879.**

82. *PANELLUS* Karst. *l.c.* p. xiv. *P. stypticus* (Bull. ex Fr.) Karst.

Status of generic name: Valid; genus accepted by many modern taxonomists.

83. *PHYLOTUS* Karst. *l.c.* p. xiv. *P. applicatus* (Batsch ex Fr.) Karst.

Discussion of lectotype: This genus as recognized by Karsten contained species of at least three of the groups since recognized as genera by later authors and because of this heterogeneity was not accepted by other investigators. For those who retain a broad concept of *Plurotus*, the genus will always be regarded as a synonym no matter which species is selected. The expedient least inconvenient for those who split *Plurotus* into smaller genera is to select a lectotype which will unquestionably reduce *Phyllotus* to synonymy under an earlier name. Since one of the most clearly delimited groups in Karsten's assemblage is the *P. applicatus* group it is a logical procedure to select the principal species of it as lectotype. The genus then becomes a synonym of *Resupinatus*

S. F. Gray as does *Scytinopsis* Singer which is based on the same type.

84. SCYTINOTUS Karst. *l.c.* p. xiv. *S. ringens* (Fr.) Karst.

Status of generic name: Valid; but genus considered congeneric with *Panus* by conservative taxonomists and congeneric with *Panellus* according to the others.

85. CAMAROPHYLLUS (Fr.) Karst. *l.c.* p. xvii. *C. pratensis* (Pers. ex Fr.) Karst.

Status of generic name: Valid; genus accepted by some taxonomists.

86. HYGROCYPE (Fr.) Karst. *l.c.* p. xvii. *H. miniata* (Fr.) Karst.

Status of generic name: Valid; genus accepted by some taxonomists.

Note: it is obvious that the spelling *Hydrocype* is merely a printer's error inasmuch as Fries is cited and Fries consistently spelled it *Hygrocybe*.

87. LEPTOTUS Karst. *l.c.* p. xvii. *L. retirugis* (Fr.) Karst.

Status of generic name: Valid; genus accepted by taxonomists under various names (*Leptoglossum*, see no. 88; or *Dictyolus*, a later synonym).

88. LEPTOGLOSSUM Karst. *l.c.* p. xvii. *L. muscigenum* (Batsch ex Fr.) Karst.

Status of generic name: This was published the same year as the Discomycete genus *Leptoglossum*, and the priority is hard to establish. However, the type species of *Leptoglossum* Karst. according to nearly all taxonomists is congeneric with the type of *Leptotus* and the latter name can be used.

89. LENTINELLUS Karst. *l.c.* p. xviii. *L. cochleatus* (Fr.) Karst.

Discussion of lectotype: *L. cochleatus* is undoubtedly the best known species of this genus and the most representative.

Status of generic name: Valid; genus accepted by some taxonomists.

90. HEMICYBE Karst. *l.c.* p. xviii. *H. ursina* (Fr.) Karst.

Status of generic name: Valid; but genus not accepted by taxonomists. It is thought that the lectotype of *Hemicybe* is congeneric with that of *Lentinellus* and the latter is preferred.

91. ROZITES Karst. *l.c.* p. xx. *R. caperata* (Pers. ex Fr.) Karst.

Status of generic name: Valid; genus accepted by many taxonomists.

92. GYMNOPIUS Karst. *l.c.* p. xxi. *G. liquiritiae* (Pers. ex Fr.) Karst.

Discussion of lectotype: Of the three species originally included by Karsten, two obviously belong in what Romagnesi calls *Fulvidula*, i.e., the section *Sapinae* of *Flammula*. The other is the one Maire transferred to *Rhodotus*. Thus it is logical to propose a species of *Fulvidula* as lectotype. Otherwise the well established and widely accepted genus *Rhodotus* would be replaced by *Gymnopilus*. This name has never been used in this sense, though it has been used in place of *Flammula*. The choice, then, is between *G. liquiritiae* and *G. picreus*. Since Murrill also prefers *G. liquiritiae* we decided in favor of it. Since Murrill used the name *Gymnopilus* for *Flammula*, not many transfers will need to be made as a result of abandoning *Fulvidula*.

Status of generic name: Valid; genus accepted by many modern taxonomists (sometimes under the name *Fulvidula*).

93. GYMNOCYBE Karst. *l.c.* p. xxii. *G. Weinmannii* (Fr.) Karst.

Discussion of lectotype: None of the species included by Karsten gives a clear idea of what that author had in mind—if anything definite—when he described the genus. *G. Weinmannii* is based on a species of Weinmann which is incompletely known. The senior author was unable to rediscover the fungus in the type locality, or to find it in the herbarium among other specimens left



by Weinmann. *G. Tammii* is either *Phylloporus rhodoxanthus* ssp. *europaeus* Sing. or, in our opinion, a *Gymnopilus*. *Gymnocybe abrupta* and *G. muricella* are both somewhat dubious species.

Status of generic name: Valid; genus based on a dubious species; therefore the genus is dubious also, particularly since it appears improbable that the type of the species can be found and restudied.

94. PHIALOCYBE Karst. l.c. p. xxii. *P. epibrya* (Fr.) Karst.

Discussion of lectotype: Both species included by Karsten are dubious both as to their characters and their generic position.

Status of generic name: Valid; but genus not accepted by taxonomists. It should be regarded as dubious unless a study of the type of the above species clarifies its generic position. (It appears improbable that this can be done.)

95. SIMOCYBE Karst. l.c. p. xxii. *S. centunculus* (Fr.) Karst.

Discussion of lectotype: We propose the above name in order to reduce the genus to synonymy with *Naucoria* in the restricted sense of the latter genus. To be consistent with Karsten's concept would require that *Simocybe* be regarded as a synonym of *Naucoria* in the broad (Friesian) sense, since his division as made left the bulk of the species in *Simocybe* and very few in *Naucoria*. It should also be pointed out that both *Simocybe* and *Naucoria* sensu Karsten contain species now placed in *Naucoria* sensu Singer, the most restricted concept of *Naucoria* yet proposed. Thus the situation here is exactly the opposite of that found for *Naematoloma* and *Hypholoma*—where Karsten did establish clear generic concepts.

Some may take the attitude that a species of the group now recognized as *Phaeocollybia* should be selected as lectotype for *Simocybe* since that group (*Naucoria lugubris* and related species) is the first distinct group given by Karsten in his account of the genus. Although we feel obligated to mention this situation here we believe that it would be unfortunate to accept *N. lugubris* or a related species as lectotype since doing so would resurrect a long-buried name which, in the concept in which it was originally proposed, was meaningless as far as the clarification of *Naucoria*

(Fr.) Quél. was concerned. Such a selection would violate our principle (5).

Status of generic name: A synonym of *Naucoria* if *N. centunculus* is accepted as lectotype.

96. *GALERULA* Karst. *l.c.* p. xxiii. *G. pityria* (Fr.) Karst.

Discussion of lectotype: Kühner states that all species of Karsten's *Galerula*, and particularly *G. pityria*, are so little known at present that it is impossible to tell whether they are *Conocybe* or *Galerina* in the sense of his concepts of these genera. Consequently he did not adopt the name *Galerula* for the group designated under the name *Galera* by Fayod but instead selected the earliest generic name which was clearly applicable to the group (the *Bryogenceae* of *Galera* [Fr.] Quél.). This was necessary because *Galera* (Fr.) Quél. is a later homonym of *Galera* Blume. *Galerula*, however, has been used as a substitute for *Galera* (Fr.) Quél. In our estimation this is the only justifiable use of the name. Since the selection of any species included in *Galerula* by Karsten would make that genus dubious, we prefer to follow Earle who indicated *G. pityria*, the most dubious of them all, as the type of the genus.

Status of generic name: Valid if used to replace *Galera* (Fr.) Quél. (which is a later homonym). This has been done by Murrill, Atkinson and R. Maire. However, if *Galerina* and *Conocybe* are both recognized, it is obvious that *Galerula* becomes a doubtful genus with little or no chance of future clarification. As such it should be rejected in favor of *Galerina* and *Conocybe*.

97. *TAPINIA* (Fr.) Karst. *l.c.* p. xxii. *T. panuoides* (Fr.) Karst.

Status of generic name: Valid; genus accepted by very few taxonomists.

98. *ROUMEGUERIA* Karst. *l.c.* p. xxiv. *R. strophosa* (Fr.) Karst.

Status of generic name: Valid; genus generally considered a synonym of *Hebeloma*. It should be noted that Karsten changed

the name to *Roumeguerites* (in 1881) and used it as a section for the atypical species of *Pholiota*, thus entirely remodeling his concept of 1879.

99. RIPARTITES Karst. *l.c.* p. xxiv. *R. tricholoma* (A. & S.) Karst.

Status of generic name: Valid; genus accepted by some authors.

100. CHITONIA (Fr.) Karst. *l.c.* p. xxv. *Agaricus poderes* Berk. & Br.

Discussion of lectotype: Since this genus is but a new status of the tribus *Chitonia* Fr. with no emendation in concept we must consider Fries' words: "Species typicae extraeuropaeae" referring to "*Agaricus podileus*" and "*Agaricus podeces*" Berk. Fries meant *A. poderes* Berk. & Br. which is probably identical with *A. podileus* and *A. trachodes* according to Boedijn.

Status of generic name: A homonym of three earlier phanero-gamic genera.

101. NAEMATOLOMA Karst. *l.c.* p. xxv. *N. sublateritium* (Fr.) Karst.

Status of generic name: Valid; genus accepted by modern taxonomists either under this name or *Hypholoma* sensu Kühner.

102. PANNUCIA Karst. *l.c.* p. xxvi. *P. noli-tangere* (Fr.) Karst.

Status of generic name: Valid; those who wish to maintain the genus *Psathyra* (which is a homonym) in a narrow sense (as in Quélet and Saccardo) should use *Pannucia* Karst. Otherwise, if the lectotype of *Pannucia* and that of *Psathyrella* are considered to be congeneric, *Pannucia* becomes a synonym of *Psathyrella*.

103. DECONICA (W. G. Smith) Karst. *l.c.* p. xxvi. *D. atrorufa* (Schaeff. ex Fr.) Karst.

Status of generic name: Valid; genus accepted by many taxonomists but by others considered a synonym of *Psilocybe*.

104. ANELLARIA Karst. *l.c.* p. xxvii. *A. separata* (L. ex Fr.) Karst.

Status of generic name: Valid; genus accepted by some authors, by others considered a section of *Panaeolus*.

105. CHALYMMOTA Karst. *l.c.* p. xxvii. *C. campanulatus* (L. ex Fr.) Karst.

Status of generic name: Synonym of *Panaeolus* (same type).

106. ONCHOPUS Karst. *l.c.* p. xxviii. *O. clavatus* (Batt. ex Fr.) Karst.

Discussion of lectotype: This species is often considered as a synonym of *Coprinus comatus*. However, by some it is considered a variety or a very closely related species.

Status of generic name: A synonym of *Coprinus*.

107. PSELLIOPHORA Karst. *l.c.* p. xxviii. *P. atramentaria* (Bull. ex Fr.) Karst.

Discussion of lectotype: Fayod restricted this genus to the above indicated species which would therefore be most desirable as the lectotype.

Status of generic name: A synonym of *Coprinus* according to all authors except Karsten and Fayod.

108. COPRINELLUS Karst. *l.c.* p. xxviii. *C. deliquescens* (Bull. ex Fr.) Karst.

Status of generic name: Valid; genus not accepted by taxonomists at present.

#### XVIII. Ex Karsten, Hymenomycetes Fennici. 1881.

109. LYOPHYLLUM Karst. Acta flor. faun. Fenn. 2 (1): 3. 1881. *L. leucophaeatum* Karst.

Status of generic name: Valid; genus accepted by modern taxonomists.

110. COPRINOPSIS Karst. *l.c.* p. 27. *C. Friesii* (Quél.) Karst.

Status of generic name: Valid; genus not accepted by any taxonomist.

111. *ARMILLARIELLA* (Karst.) Karst. *l.c.* p. 4. *A. mellea* (Fl. D. ex Fr.) Karst.

Discussion of lectotype: One of the three species included by Karsten belongs to a genus that, if accepted, has no other generic name than *Armillariella* whereas the other two are in the Fries-Saccardoan scheme as well as in the opinion of modern authors not generically different from *Pleurotus* (Fr.) Quél. sensu str. According to our principle (3), p. 245, we have proposed *A. mellea* as lectotype.

Status of generic name: Valid; genus accepted by many taxonomists at present.

**XIX. Ex Spegazzini, Ann. Soc. Cient. Argent. 10-12. 1880-1881.**

112. *OUDEMANSIA* Speg. *l.c.* 10: 280. 1880. *O. platensis* (Speg.) Speg.

Status of generic name: A homonym of *Oudemansia* Miq. (1857).

113. *OUDEMANSIELLA* Speg. *l.c.* 12: 24. 1881. *O. platensis* (Speg.) Speg.

Status of generic name: Valid unless material on which the type species was based represents a pathological condition, as Rick thought. Rick's own specimens are not deformed by a parasite, however, and agree with normal material collected in Florida. The characters described by Spegazzini are to be regarded as inexact description rather than an actual anomaly. Consequently *Oudemansiella* is here regarded as a valid genus.

**XX. Ex Berkeley & Broome, Ann. Mag. Nat. Hist. V. 12. 1883.**

114. *LACCARIA* Berk. & Br. *l.c.* p. 370. *L. laccata* (Scop. ex Fr.) Berk. & Br.

Status of generic name: Valid; genus accepted almost unanimously by taxonomists.

**XXI. Ex Bresadola, Schulzeria. 1886.**

115. SCHULZERIA Bres. *l.c.* p. 7. *S. rimulosa* Schulz. & Bres.  
Status of generic name: Valid.

**XXII. Ex Quélet, Enchiridion Fungorum. 1886.**

116. GYROPHILA Quélet. *l.c.* p. 9. *G. equestris* (L. ex Fr.) Quélet.

Status of generic name: Synonym of *Tricholoma* (same type), if the latter genus is conserved (as appears to be desirable); if *Tricholoma* is not conserved, *Gyrophila* becomes a synonym of *Cortinellus* unless the lectotypes of both genera are considered not to be congeneric, in which case *Gyrophila* would be valid.

117. OMPHALIA Quélet. *l.c.* p. 19. *O. infundibuliformis* (Schaeff. ex Fr.) Quélet.

Status of generic name: A homonym of *Omphalia* (Pers.) ex Gray, and at the same time a synonym of *Clitocybe* (Fr.) Quélet. (same type).

118. OMPHALINA Quélet. *l.c.* p. 42. *O. umbellifera* (L. ex Fr.) Quélet.

Discussion of lectotype: When selecting the lectotype we had to discard the species belonging to such sections as have recently been transferred to *Clitocybe* (species such as *O. hydrogramma*, *O. ventosa*, *O. epichysium*, *O. rustica*, *O. xanthophylla*, *O. griseo-pallida*) and species transferred to other genera (*O. maura*, *O. scyphoides*, *O. fibula*, *O. gracilis*, *O. integrella*, etc.). When all these are excluded there remains, in addition to some dubious species, the group including *O. umbellifera* and *O. philonotis* which forms *Omphalia* (Fr.) Quélet. sensu str. Singer. It is technically necessary under the rules to adopt the name *Omphalina* (instead of *Omphalia*) for this group and whatever groups the various authors will choose to combine with it. The change in the name is so slight that we do not feel justified in asking that the genus *Omphalia* (Fr.) Quélet. be conserved against *Omphalia* (Pers.) Gray and *Omphalina* Quélet. The change to *Omphalina* cannot be regarded as inconvenient because the necessary combinations have

nearly all been made, and in either case the genus and most of the transfers are credited to Quélet.

Status of generic name: Valid; genus accepted by most taxonomists (usually as *Omphalia* and in a broad rather than a restricted sense).

119. CALATHINUS Quélet. *l.c.* p. 46. *C. hypnophilus* (Berk.) Quélet.

Status of generic name: A homonym of *Calathinus* Rafin. (1836).

120. RHODOPHYLLUS Quélet. *l.c.* p. 57. *R. lividus* (Bull. ex Fr.) Quélet.

Discussion of lectotype: Since none of the species included in *Rhodophyllus* by Quélet would, if adopted as lectotype, serve to maintain this genus against the earlier smaller genera (*Nolanea*, *Leptonia*, *Eccilia*), we are content to choose the most conspicuous species of the subgenus *Entoloma* (Fr.) Quélet.

Status of generic name: A synonym of *Entoloma* (same type). However, *Rhodophyllus* is proposed by us for conservation against *Entoloma* if used in the sense of Quélet (including the majority of the species of *Nolanea*, *Leptonia* and *Eccilia*).

121. DRYOPHILA Quélet. *l.c.* p. 66. *D. squarrosa* (Muell. ex Fr.) Quélet.

Discussion of lectotype: Whatever type be selected, *Dryophila* would either become a synonym of *Rozites*, *Pholiota*, *Flammula* or *Gymnopilus* or would replace one of the modern names such as *Agrocybe*, *Pholiotina*, *Phaeomarasmius* or *Galerina*. The choice of *D. squarrosa* takes into account merely the fact that it is the best known and most widely distributed species of the whole group.

Status of generic name: A synonym of *Pholiota* (same type).

122. HYLOPHILA Quélet. *l.c.* p. 98. *H. fastibilis* (Fr.) Quélet.

Discussion of lectotype: As in the foregoing genus we can at present see no advantage (according to our principle (4), p. 245) in attempting to establish this genus on any other lectotype than

*H. fastibilis*. Whatever lectotype is chosen, *Hylophila* either becomes a synonym of *Hebeloma*, *Naucoria*, *Flammula*, *Deconica* or *Tubaria*, or replaces one of the modern genera (which would be undesirable) such as *Agrocybe*, *Phacomarasmius*, *Alnicola*, *Galerina*, *Phaeocollybia* or *Macrocystidia*.

123. PLUTEOLUS Quél. *l.c.* p. 104. *P. reticulatus* (Fr.) Gill.

Status of generic name: Homonym and synonym of *Pluteolus* (Fr.) Gill.

124. PRATELLA Quél. *l.c.* p. 109. *P. campestris* (L. ex Fr.) Gray.

Status of generic name: Homonym and synonym of *Pratella* (Pers.) ex Gray and consequently a synonym of *Agaricus* L. ex Fr. sensu Karst. (same type).

125. GEOPHILA Quél. *l.c.* p. 111. *G. aeruginosa* (Curt. ex Fr.) Quél.

Discussion of lectotype: The situation is analogous to that discussed under nos. 121-122.

Status of generic name: Synonym of *Stropharia* (same type)

126. DROSOPHILA Quél. *l.c.* p. 118. *D. Candolleana* (Fr.) Quél.

Status of generic name: Synonym of *Hypholoma* (same type), and in the opinion of many authors congeneric with type of *Psathyrella*.

127. COPRINARIUS Quél. *l.c.* p. 118. *C. campanulatus* (L. ex Fr.) Quél.

Status of generic name: Synonym of *Panacolus* (same type).

128. DICTYOLUS Quél. *l.c.* p. 139. *D. retirugis* (Bull. ex Fr.) Quél.

Status of generic name: Synonym of *Leptotus* Karst. (same type).



129. PLEUROTUS Quél. *l.c.* p. 147. *P. ostreatus* (Jacq. ex Fr.) Quél.

Status of generic name: Homonym and synonym of *Pleurotus* (Fr.) Quél. (same type).

**XXIII. Ex Patouillard, Hyménomycètes d'Europe. 1887.**

130. MUCIDULA Pat. *l.c.* p. 95. *M. mucida* (Schrad. ex Fr.) Pat.

Status of generic name: Valid; genus accepted by many modern taxonomists, by others considered congeneric with type of *Oudemansiella* which has priority.

131. MELALEUCA Pat. *l.c.* p. 96. *M. vulgaris* Pat.

Status of generic name: Homonym of *Melaleuca* L. (1767).

132. ANDROSACEUS Pat. *l.c.* p. 105. *A. rotula* (L. ex Fr.) Pat.

Status of generic name: Synonym of *Marasmius* (same type).

133. DOCHMIOPUS Pat. *l.c.* p. 113. *D. variabilis* (Pers. ex Fr.) Pat.

Status of generic name: Valid; genus accepted by some modern taxonomists.

134. LACRYMARIA Pat. *l.c.* p. 122. *L. velutina* (Pers. ex Fr.) Pat.

Status of generic name: Valid; genus accepted by many modern taxonomists.

135. GEOPETALUM Pat. *l.c.* p. 127. *G. petaloides* (Bull. ex Fr.) Pat.

Status of generic name: Valid; genus accepted by many modern taxonomists (under the name of *Acanthocystis*).

136. NEUROPHYLLUM Pat. *l.c.* p. 129. *N. clavatum* (Pers. ex Fr.) Pat.

Status of generic name: Synonym of *Gomphus* (same type).

**XXIV. Ex Quélet, Flore Mycologique de France. 1888.**

137. *PHYLLPORUS* Quél. *l.c.* p. 409. *P. Pelletieri* (Lév.) Quél.

Status of generic name: Valid; genus accepted by most taxonomists.

**XXV. Ex Patouillard, Bull. Soc. Myc. France. 1888.**

138. *LEU(CO)COPRINUS* Pat. Bull. Soc. Myc. Fr. 4: 26. 1888.

*L. flavipes* Pat.

Status of generic name: Valid; but type species considered to be congeneric with either *Hiatula* or *Lepiota* by many taxonomists.

**XXVI. Ex Schroeter, in Cohn, Kryptogamen-Flora von Schlesien, Pilze. 1885-1889.**

139. *LIMACIUM* (Fr.) Schroet. *l.c.* p. 530. *L. cburneum* (Bull. ex Fr.) Schroet.

Status of generic name: A synonym of *Hygrophorus* (same type).

140. *LACTARIA* Pers. ex Schroet. *l.c.* p. 534. *L. deliciosa* (L. ex Fr.) Schroet.

Status of generic name: A synonym of *Lactarius* (same type).

141. *LACTARIELLA* Schroet. *l.c.* p. 544. *L. lignyota* (Fr.) Schroet.

Status of generic name: Valid; but genus not accepted by taxonomists (the type considered congeneric with type of *Lactarius*).

142. *RUSSULINA* Schroet. *l.c.* p. 550. *R. lutea* (Huds. ex Fr.) Schroet.

Status of generic name: Synonym of *Russula* (same type).

143. *CORTINIOPSIS* Schroet. *l.c.* p. 566. *C. lacrimabundus* (Bull. ex Fr.) Schroet.

Discussion of lectotype: This species is the same as *Agaricus velutinus* Pers. ex Fr.

Status of generic name: A synonym of *Lacrymaria* (same type).

144. *ASTROSPORINA* Schroet. *l.c.* p. 576. *A. praetervisa* Quél.

Status of generic name: A synonym of *Clypeus* (Britz.) Fay. (same type) unless the latter was published (a few weeks) later; in which case *Astrosporina* would be a valid genus though not accepted as different from *Inocybe* by most authors at present.

145. *HYPORHODIUS* (Fr.) Schroet. *l.c.* p. 613. *H. lividus* (Bull. ex Fr.) Schroet.

Status of generic name: Synonym of *Rhodophyllus* Quél. and *Entoloma* (Fr.) Quél. (same type).

146. *RHODOSPORUS* Schroet. *l.c.* p. 617. *R. cervinus* (Schaeff. ex Fr.) Schroet.

Status of generic name: Synonym of *Pluteus* Fr. (same type).

147. *RUSSULIOPSIS* Schroet. *l.c.* p. 622. *R. laccata* (Scop. ex Fr.) Schroet.

Status of generic name: Synonym of *Laccaria* Berk. & Br. (same type).

## XXVII. Ex Karsten, Basidsvampar. 1889.

148. *ONCOPUS* Karst. *l.c.* p. 256. *O. clavatus* (Batt. ex Fr.) Karst.

Status of generic name: Merely another spelling of *Onchopus* Karst. 1879.

## XXVIII. Ex Patouillard, Journal de Botanique 3. 1889.

149. *CRINIPELLIS* Pat. *l.c.* p. 336. *C. stipitaria* (Fr.) Pat.

Status of generic name: Valid; genus accepted by many taxonomists.

## XXIX. Ex Patouillard, Bull. Soc. Myc. France 5. 1889.

150. *CYMATELLA* Pat. *l.c.* p. 193. *C. marasmioides* (B. & C.) Pat.

Status of generic name: Valid; genus accepted by some taxonomists.

**XXX. Ex Fayod, Prodrome d'une Histoire Naturelle des Agaricinés. 1889.**

151. DELICATULA Fay. Ann. Sc. Nat. VII. 9: 313. 1889.  
*Omphalia integrella* (Pers. ex Fr.) Quél.

Status of generic name: Valid; genus accepted by modern taxonomists.

152. LENTINELLUS Fay. *l.c.* p. 336. *Lentinus cochleatus* (Pers. ex Fr.) Quél.

Status of generic name: Homonym and synonym of *Lentinellus* Karsten (same type).

153. OMPHALOTUS Fay. *l.c.* p. 338. *Pleurotus olcarius* (D.C.) Gill.

Status of generic name: Valid; genus not accepted by most taxonomists.

154. UROSPORA Fay. *l.c.* p. 338. *Pleurotus mitis* (Pers. ex Fr.) Quél.

Discussion of lectotype: *P. mitis* is the only species included by Fayod that is well enough studied at present to comply with our principle (4), p. 245.

Status of generic name: Valid; genus not accepted by taxonomists.

155. PLEUROTELLUS Fay. *l.c.* p. 339. *Pleurotus hypnophilus* (Berk.) Quél. sensu Fay.

Status of generic name: Valid; genus accepted by many taxonomists either under this name or *Calathinus*.

156. CYSTODERMA Fay. *l.c.* p. 351. *Lepiota amianthina* (Scop. ex Fr.) Karst.

Status of generic name: Valid; genus accepted by many taxonomists, by some considered congeneric with *Lepiota* or *Armillaria*.

157. FUSISPORIA Fay. *l.c.* p. 351. *Lepiota sistrata* (Fr.) Quél.

Status of generic name: Valid but not likely to be taken up since the present interpretation of *L. sistrata* does not bear out

Fayod's statements and is hardly generically different from *Leptota* sensu str.

158. FLAMMOPSIS Fay. l.c. p. 356. *F. lubrica* (Fr.) Fay.

Status of generic name: Valid and will replace *Flammula* (Fr.) Quél. if the latter is not conserved. The lectotypes of *Flammopsis* and *Flammula* are considered to be congeneric.

159. CONOCYBE Fay. l.c. p. 357. *Galera tenera* (Schaeff. ex Fr.) Quél.

Status of generic name: Valid; genus accepted by many taxonomists.

160. AGROCYBE Fay. l.c. p. 358. *Pholiota praecox* (Pers. ex Fr.) Quél.

Discussion of lectotype: This species was designated as the type by Fayod himself (though erroneously as *Naucoria praecox*). It should be kept in mind that it is a veiled species with pleurocystidia.

Status of generic name: Valid; genus accepted by many taxonomists.

161. PHOLIOTINA Fay. l.c. p. 359. *Pholiota blattaria* (Fr.) Gill.

Status of generic name: Valid; genus accepted by some modern taxonomists.

162. RYSSOSPORA Fay. l.c. p. 361. *Flammula apicrea* (Fr.) Gill.

Discussion of lectotype: It is not entirely clear just what Fayod intended to include in this genus. *Flammula apicrea* does not appear to be accepted by all authors in the same sense, but Bulliard's plate, cited by Fries, certainly represents either *Gymnopilus* or *Flammula*. Both these genera have priority over *Ryssospora*. Even if *Flammula* is not conserved, *Flammopsis* would obviously be preferred. Konrad and Maublanc think that *F. apicrea* (Fr.) Gillet is merely a mild form of *F. alnicola*. If this is true, as it may well be, it is evident that Fayod did not intend to include it in his genus since he described the spores as rough. Another spe-

cies included by Fayod is "*Flammula marginata* Batsch" (should read *Pholiota marginata* (Batsch ex Fr.) Quél.). This is now often called *Galerina marginata* (Batsch ex Fr.) Kühner. In this case Fayod may actually have studied the true *G. marginata*, but its characters are not in good agreement with the diagnosis of *Ryssospora* as given by Fayod. *Pholiota mustelina*, also cited by Fayod, was not well known to him since he added "(cuticule nulle?)." The last species indicated by Fayod, *Naucoria hilaris*, is now considered as either *Naucoria* sensu lato (in which case there would be no need of a new generic name) or a *Phacocollybia*. However, the latter name should not be dropped in favor of *Ryssospora* because the description of *Agaricus hilaris* by Fries and others does not fit in Fayod's diagnosis of *Ryssospora*. Thus only *F. apicrea* can be logically proposed as lectotype.

Status of generic name: Valid, but a synonym of either *Gymnopilus* or *Flammula*, very likely the former but possibly the latter if *F. apicrea* is really a mild *F. alnicola*.

163. MYXOCYBE Fay. l.c. p. 361. *Pholiota radicata* (Bull. ex Fr.) Quél.

Status of generic name: Valid; genus not accepted by other taxonomists.

164. CLYPEUS (Britz.) Fay. l.c. p. 562. *Inocybe praetervisa* Quél.

Status of generic name: We are unable to establish the exact date of Fayod's publication in 1889; consequently it may be that this is a later synonym of *Astrosporina* Schroet. (1889). Neither name has found much acceptance among taxonomists. Heim, Kühner, Kauffman, Ricken and Lange, the most distinguished specialists in this group, have not distinguished it generically from *Inocybe*.

165. SCHINZINIA Fay. l.c. p. 365. *S. pustulata* Fay.

Status of generic name: Valid, but the species has not been collected since and the genus has never been clarified further.

166. CYPHELLOPUS Fay. *l.c.* p. 365. *Agaricus acetabulosus* Sow.

Status of generic name: Fayod stated that Berkeley established the genus *Acetabularia* on this same type, but actually Berkeley described it as a subgenus, and this was raised to generic status by Saccardo in 1887. As such it is a homonym of *Acetabularia* Lamour., an algal genus. *Cyphellopus* Fay., therefore, is a new name for *Acetabularia* (Berk.) Sacc., a genus containing one species and that one so poorly known that the genus must be considered of doubtful standing.

167. DERMOCYBE (Fr.) Fay. *l.c.* p. 372. *D. cinnamomea* (L. ex Fr.) Fay.

Status of generic name: Valid, but type considered congeneric with that of *Cartinarius* by most authors.

168. HYDROCYPE (Fr.) Fay. *l.c.* p. 372. *H. decipiens* (Pers. ex Fr.) Fay.

Status of generic name: A homonym of *Hydrocype* Karst. (a misspelling of *Hygrocype*) and besides considered congeneric with *Cortinarius* by most authors.

169. TELAMONIA (Fr.) Fay. *l.c.* p. 373. *T. torva* (Fr.) Fay.

Status of generic name Same as for *Dermocybe*.

170. SPHAEROTRACHYS Fay. *l.c.* p. 374. "*Myxacium*" *liquidum* Fr.

Status of generic name: Same as for *Dermocybe*.

171. MYXACIUM (Fr.) Fay. *l.c.* p. 374. *Myxacium collinitum* (Pers. ex Fr.) Fay.

Status of generic name: Same as for *Dermocybe*.

172. PHLEGMACIUM (Fr.) Fay. *l.c.* p. 375. *P. decoloratum* (Fr.) Fay.

Status of generic name: Same as for *Dermocybe*.

173. ATYLOSPORA Fay. *l.c.* p. 376. *Psathyra corrugis* (Fr.) Quél.

Status of generic name: Valid, but not accepted by any taxonomist other than Murrill. The main character on which the genus is based (sessile basidiospores) appears to have been due to faulty observation and the lectotype is generally considered congeneric with that of *Psathyra* (Fr.) Quél. (which is a later homonym). It is also considered congeneric with the lectotype of *Psathyrella* by many authors, and the latter name has priority.

174. PLUTEOPSIS Fay. *l.c.* p. 377. "*Agaricus phellospermus* Secret." "

Status of generic name: Valid, but not accepted by taxonomists. It is apparently identical with *Psathyrella* (Fr.) Quél.

175. PSILOCYBE Fay. *l.c.* p. 377. "*Psilocybe foeni-sicci* Pers." <sup>10</sup>

Discussion of lectotype: The only species of those indicated by Fayod that fits the original diagnosis is *A. foenisecii*.

Status of generic name: A homonym of *Psilocybe* (Fr.) Quél.

176. GLYPTOSPORA Fay. *l.c.* p. 377. *Agaricus velutinus* Pers. ex Fr.

Status of generic name: Synonym of *Lucrymaria* Pat. (same type).

177. LENTISPORA Fay. *l.c.* p. 379. *Coprinus tomentosus* (Bull. ex Fr.) Fr.

Status of generic name: Valid, but genus not accepted by taxonomists at present.

178. EPHEMEROCYBE Fay. *l.c.* p. 380. *Coprinus ephemerus* (Bull. ex Fr.) Fr.

Status of generic name: Same as for no. 177.

<sup>9</sup> *Agaricus phellospermus* Secr. is meant.

<sup>10</sup> *Agaricus foenisecii* Pers. ex Fr. is meant.



179. GYMNOGOMPHUS Fay. *l.c.* p. 385.

Status of generic name: Hyponym (the description is not distinctive enough to exclude *Gomphidius*, and no species belonging here was indicated).

180. HEXAJUGA Fay. *l.c.* p. 389. *Clitopilus prunulus* (Scop. ex Fr.) Quél.

Status of generic name: Synonym of *Clitopilus* (same type).

181. OCTOJUGA Fay. *l.c.* p. 390. *Claudopus variabilis* var. Karst. Myc. Fenn. p. 112.

Status of generic name: Valid; genus accepted by some modern taxonomists; by others not separated from *Clitopilus*.

**XXXI. Ex O. Kuntze, Revisio Generum Plantarum. 1891-1898.**182. GOMPHOS Kuntze, *l.c.* 2: 853. 1891. *Cortinarius castaneus* (Bull. ex Fr.) Fr.

Status of generic name: A homonym of *Gomphus* (Pers.) ex Gray (1821).

183. MASTOLEUCOMYCES Batt. ex Kuntze, *l.c.* 2: 860. 1891. *Mastoleucomyces ramentaceus* (Bull. ex Fr.) Kuntze.

Status of generic name: Valid, but genus not accepted by taxonomists.

184. ORCELLA Batt. ex Kuntze, *l.c.* 2: 863. 1891. *Orcella obesa* (Batsch) ex Kuntze.

Status of generic name: Since *O. obesa* is generally considered a synonym of *Clitopilus prunulus*, *Orcella* is a synonym of *Clitopilus*.

185. POCILLARIA P. Browne ex Kuntze, *l.c.* 2: 865. 1891. *Pocillaria crinita* (L. ex Fr.) Kuntze.

Status of generic name: Valid, but type considered to be congeneric with lectotype of *Lentinus* by all taxonomists at present.

186. PSEUDOFARINACEUS Kuntze, *l.c.* 2: 867. 1891. *Pseudo-farinaceus vaginatus* (Bull. ex Fr.) Kuntze.

Status of generic name: Synonym of *Vaginata* Gray (same type).

187. MASTOCEPHALUS Batt. ex Kuntze, *l.c.* 2: 859. 1891. *Mastocephalus cepaestipes* (Bolt. ex Fr.) Kuntze.

Status of generic name: Valid, but genus congeneric with *Leucocoprinus* Pat. and perhaps with *Lepiota* or *Hiatula*.

188. LATZINAEA Kuntze, *l.c.* 2: 857. 1891. *L. pascua* (L. ex Fr.) Kuntze.

Status of generic name: Synonym of *Nolanea* (Fr.) Quél. (which is not a homonym as Kuntze thought). Both are based on the same type.

189. LACTIFLUUS (Fr.) Kuntze, *l.c.* 2: 856. 1891. *L. deliciosus* (L. ex Fr.) Kuntze.

Status of generic name: Synonym of *Lactarius* Gray (same type).

190. CLARKEINDA Kuntze, *l.c.* 2: 848. 1891. *C. poderes* (Berk. & Br.) Kuntze.

Status of generic name: Valid.

191. CHAMAE CERAS Reb. ex Kuntze, *l.c.* 3<sup>2</sup>: 454. 1898. *Chamaeceras androsaccus* (L. ex Fr.) Kuntze.

Status of generic name: Valid, but type of genus considered congeneric with the type of *Marasmius* by practically all authors at present.

192. DENDROSARCUS Paul. ex Kuntze, *l.c.* 3<sup>2</sup>: 462. 1898. *D. nigrescens* Paul. ex Kuntze.

Status of generic name: Synonym of *Pleurotus* and *Crepidopus*, and so intended by Kuntze. *D. nigrescens* Paulet is *Pleurotus ostreatus* (Jacq. ex Fr.) Quél.

**XXXII. Ex Patouillard, Plantes . . . Tunisie. 1897 and Essai taxonomique. 1900.**

193. MELANOLEUCA Pat. Cat. rais. Pl. Cell. Tun. p. 22. 1897  
*M. vulgaris* Pat.

Discussion of lectotype: *Melanoleuca* is merely a new name for *Melaleuca*, so the lectotype of the latter must be retained.

Status of generic name: Valid; genus accepted by many modern taxonomists (and used by Murrill in a broader sense to replace *Tricholoma*).

194. DICTYOPANUS Pat. Essai, p. 137. 1900. *Polyporus rhididium* Berk.

Status of generic name: Valid; genus accepted by some taxonomists.

195. HYMENOGLOEA Pat. Essai, p. 146. 1900. *H. Riofrioi* (Pat.) Pat.

Status of generic name: Valid; genus accepted by some taxonomists.

196. MELANOTUS Pat. Essai, p. 175. 1900. *M. bambusinus* Pat.

Status of generic name: Valid; genus accepted by some taxonomists.

**XXXIII. Ex Eichelbaum, Pilzflora Ostusambargeb. 1906.**

197. AGARICHAETE Eich. Verh. Naturw. Ver. Hamburg 3.  
XIV: 58. 1906. *A. mirabilis* Eich.

Status of generic name: Valid; genus not found since described.

**XXXIV. Ex Ricken, Die Blätterpilze, 1910-1915.**

198. INOLOMA (Fr.) Ricken, l.c. p. 149. 1912. *I. violaceus* (L. ex Fr.) Ricken.

Status of generic name: Synonym of *Cortinarius* (same type).

DISCUSSION OF THE NOMINA GENERICA CONSERVANDA  
PROPOSED BY R. MAIRE (1935)

DICTYOLUS Quél. (1886) against *Leptoglossum* Karst. (1879).

Since the generic name *Leptotus* Karst. (1879) is also available and is certainly not homonymous (whereas *Leptoglossum* might be so considered), we do not believe that *Dictyolus* Quél. deserves to be conserved. The species concerned are so rare that none of the names involved has been established by usage.

AGARICUS L. ex Fr. (1821) em. Karst. against *Psalliota* (Fr.) Quél. and *Pratella* Gray.

If the type we have proposed (no. 1) is adopted—and we cannot see which other species of *Agaricus* could be chosen and still be historically logical—the genus *Agaricus* in the sense of Karsten and Saccardo does not need conservation. On the contrary, if anyone would prefer *Psalliota* or *Pratella*, he would need to obtain the sanction of the International Congress for his choice.

FLAMMULA (Fr.) Quél. (1872) against *Ryssospora* Fay. (1889), *Gymnopilus* Karst. (1879) and *Visculus* Earle (1909).

The conservation of *Flammula* (Fr.) Quél. appears to be very desirable from the point of view of some mycologists. However, as far as we can see, it depends on agreement with the phanero-gamic commission whether the name *Flammula* D. C. is considered definitely out of use. This appears to be the attitude of Maire and the Nomenclature Commission of the British Mycological Society. On the condition that such an agreement can be made, we join the others in proposing that *Flammula* (Fr.) Quél. be conserved against the genera indicated by Maire and also against *Gymnocybe* Karst. (1879) and *Flammopsis* Fay. (1889).

GALERA (Fr.) Quél. (1872) against *Conocybe* Fay. (1889).

Since Kühner, in the most extensive monograph of the groups involved, has chosen and defined the genera *Conocybe* and *Galerina*, we cannot see any advantage in maintaining the old

generic name *Galera* which is ambiguous in the light of modern taxonomy. The name *Galcrula* Karsten is available to all who wish to use the genus in the concept of Quélet and Saccardo, and the combinations of any consequence have already been made. Since there is no real need to conserve *Galera* (Fr.) Quél., we do not believe it advisable to act on the assumption that *Galera* Blume (1825) is unlikely to be taken up again by phanerogamic botanists. If *Galera* (Fr.) Quél. were conserved, the question of a lectotype for it would be very delicate. From an historical point of view, and in line with the procedure outlined in the present Rules, it should be a species included by Fayod in his emendation, which was the first emendation of the genus along the lines we now accept. If this is kept in mind, *Galera* (Fr.) Quél. must be retained for the species now placed in *Galerina* Earle by Kühner, Singer and others. Consequently, the lectotype, *G. tenera* (which is a *Conocybe*), proposed by R. Maire and Wakefield, is untenable. If *Galera* (Fr.) Quél. is not conserved, it is automatically not valid and the question of selecting a lectotype for it is of no importance.

PANUS Fr. (1836) against *Rhipidium* Wallr. (1833).

Notwithstanding the fact that this proposal originated from an error, we feel that it is necessary to support it because of other reasons. *Rhipidium* is by no means a *Panus* or *Panellus* but instead a *Schizophyllum* (*Rhipidium stypticum* Wallr. = *Schizophyllum commune* Fr.). Therefore *Panus* does not need to be conserved against it. If our scheme of type species is accepted, however, the genus *Panus* is in need of conservation against *Pleuropus* (Pers.) ex Gray. Failure to do this would require that all species be transferred. Some are very important, almost cosmopolitan, of economic significance and consequently well known in the literature of fields other than taxonomic mycology. In addition, the names *Pleuropus* and *Pleurotus* together in the same family of the Agaricales would cause errors and misunderstanding. Since a selection of any other lectotype for *Pleuropus* would merely mean proposing some other well known name for conservation (see no. 9 of our list) the situation could not be resolved in that way. Consequently we consider it vitally im-

portant that the genus *Panus* Fr. be conserved against *Pleuropus* (Pers.) ex Gray.

TRICHOLOMA (Fr.) Quél. (1872) against *Cortinellus* Roze (1876), *Gyrophila* Quél. (1886) and *Monomyces* Earle (1909).

We agree that conservation of this genus would be very beneficial for the continuity of mycological nomenclature, and we support it wholeheartedly.

VOLVARIA (Fr.) Quél. (1872) against *Pseudofarinaceus* Earle non Kuntze 1909.

If *Volvaria* should be conserved at all, it should be conserved against *Volvariopsis* Murrill (1911). Though *Pseudofarinaceus* Earle non Kuntze is claimed to be the correct determination of Battara's "genus," it is important that the first mention of this pre-Friesian name after 1821 was made by Kuntze, and therefore it has to be adopted in Kuntze's sense. However, *Pseudofarinaceus* Kuntze non Earle is not a *Volvaria* (see no. 186 of our lectotypes). This makes Earle's *Pseudofarinaceus* a homonym. Since Murrill has made most of the important transfers to *Volvariopsis*, we are not convinced that the conservation of *Volvaria* is really vital though it may be desirable for sentimental reasons.

PAXILLUS Fr. (1836) against *Rhymovis* Pers (1825) and *Ruthea* Opat. (1836).

*Rhymoxis* Pers. was only conditionally proposed by Persoon and is not a validly published name. But *Ruthea* Opat. may (or may not) have priority over *Paxillus* and therefore, in order to maintain continuity and avoid transfers, we should conserve *Paxillus* Fr. If between now and the time for a decision on this proposal it can be established that *Paxillus* Fr. has priority over *Ruthea*,<sup>11</sup> it would, of course, not be necessary to conserve *Paxillus*.

<sup>11</sup> Both *Paxillus* and *Ruthea* were proposed in dissertations for the doctor's degree early in 1836, and *Ruthea* was contained in the paper that was accepted by the University earlier than the paper containing *Paxillus*. But according to Art. 36 of the Rules only the actual date of the publication is decisive, and we have not been able to establish this exactly.

## NOMINA GENERICA CONSERVANDA PROPOSITA

In addition to those genera proposed by R. Maire whose approval we have indicated above, we believe it is necessary to propose the following generic names for conservation:

CORTINARIUS Fr. (1836) against *Cortinaria* Gray (1821).

*Cortinarius* is now almost unanimously used. According to Art. 70, 3 of the International Rules, *Cortinarius* is not merely an orthographic variant of *Cortinaria*; therefore all the species not indicated in Gray would have to be transferred to it (excepting those mentioned under *Cortinaria* by Murrill). This would cause innumerable new combinations.

PLEUROTUS (Fr.) Quél. (1872) against *Crepidopus* (Pers.) ex Gray (1821).

The name *Crepidopus* would replace *Pleurotus* for such species as *P. ostreatus*, *P. Erynqii*, *P. dryinus* and other important economic species. This would not only necessitate new combinations for fungi well known to the general public as well as mycologists but would introduce a perpetual source of confusion in generic names, i.e. *Crepidopus* and *Crepidotus*. This is already evident in the literature. Earle took up Gray's *Crepidopus* but spelled it (wrongly) *Crepidotus*.

The following two genera are proposed to be conserved conditionally. This seems to be quite an innovation at first glance, but it actually is not foreign to the rules, since we do not believe that the conservation of a certain genus in a certain sense only should be illegal. Since the proposals made here will stabilize existing nomenclature they are in line with the principles on which the rules have been formulated and if technicalities against such proposals are found they should be removed. Such conservation as this is necessary in the two cases proposed in order to achieve an acceptable compromise between the conservative and the modern school of taxonomists who cannot agree on a single solution (in each case) that is satisfactory to both. In one case a genus is proposed to be conserved for the benefit of the conservative taxon-

omists (*Marasmius*) and in the other for the benefit of those adhering to modern taxonomy (*Rhodophyllus*).

1. *MARASMIUS* Fr. (1836) sensu lato, against *Micromphale* Gray (1821).

Reasons: The section *Gloeonemi* Kühner of the genus *Marasmius* contains the proposed type species of Gray's genus *Micromphale*. Some modern authors consider this section a genus. For these authors the name *Micromphale* is welcome and does not interfere with the use of the name *Marasmius* in a more restricted sense. However, in the Friesian sense *Micromphale*, as a name for *Marasmius*, has priority and would have to be substituted unless the latter is conserved. The substitution of *Micromphale* for *Marasmius* would involve hundreds of transfers besides doing away with one of the most widely used generic names in the gill fungi. Consequently, it is highly desirable to conserve *Marasmius*.

Since the modern authors who recognize Kühner's section *Gloeonemi* as a genus must abandon the name which they originally used (*Heliumyces*) a new name will have to be given if *Micromphale* is not left available to them. If *Marasmius* is conserved against *Micromphale* as proposed here both groups of taxonomists will enjoy a maximum of continuity.

2. *RHODOPHYLLUS* Quél. (1886) sensu lato against *Entoloma* (Fr.) Quél., *Leptonia* (Fr.) Quél. (1872), *Nolanea* (Fr.) Quél. (1872), *Eccilia* (Fr.) Quél. (1872), and *Claudopus* (Fr.) Gill. (1876).

Reasons: The reasons that make it desirable to conserve *Rhodophyllus* Quélet against the above mentioned Friesian-Saccardoan genera have been enumerated in R. Singer, *Farlowia* 2: 50-51. 1945. Here also we propose that the genus be conserved in the original sense, i.e. to include all the Rhodogoniosporaceae known to Quélet. This is the way it was used by Quélet, and this usage has been followed by all the modern authors who have taken up the name. This proposed action is desirable in order to avoid the possibility of endless name juggling in the future by those who might want to insist that one of the genera proposed by Quélet in 1872 be used in place of *Rhodophyllus*. It is true that Quélet



should not have used a new name in 1886 but in the meantime it has become established in the literature and in our estimation nothing would be gained by abandoning it for purely legal reasons. If conserved with the above understanding *Rhodophyllus* can be discarded by those who still maintain that *Entoloma*, *Nolanea*, *Leptonia*, *Eccilia* and *Claudopus* are separate genera, and the earlier generic names of Quélet can be neglected by those who follow Quélet, Lange and Romagnesi in considering them all congeneric.

#### CONCLUSIONS

Since we consider the adoption of the *Species Lectotypicae Propositae* for the agarics as the most urgent need in clarifying the nomenclature of the gill fungi, the list published in this article is respectfully submitted for the consideration of mycologists in general and the next International Botanical Congress in particular.

The list of *Nomina Generica Conservanda Proposita* by R. Maire has been critically discussed, and only four out of eight genera usually considered as gill fungi (agarics), namely *Flammula*, *Panus*, *Tricholoma* and *Paxillus*, are, in our opinion, worth or in need of conservation. *Volvaria* should be either conserved against *Volvariopsis* or abandoned in favor of it (no definite stand is taken by us as long as the agreement with the lichenological commission has not been reached). In addition, we propose the adoption of four other genera not mentioned in Maire's list, namely *Cortinarius*, *Pleurotus*, *Marasmius* (sensu originali), and *Rhodophyllus* (sensu originali).

We propose the rejection of the proposal to consider the Friesian subgenera and tribes as genera.

The above proposals will be submitted to the Executive Committee of the next International Botanical Congress on Nomenclature either in the form adopted in the present paper, or (if improvements are suggested by other mycologists) in an emended form. Our proposals are at the same time intended to be studied and discussed by the permanent groups of the Special Committee for Mycological Nomenclature. We believe that the publication of these proposals at the present date will help to speed up the procedure, giving all mycologists interested in and concerned with

these problems ample time to check on our proposals, and either improve them, or adopt them and eventually vote on them.

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# INDEX

The index is to the genera represented in the list of lectotypes and those proposed for conservation or rejection. The figures after the generic names in this index are the numbers under which the names appear in our list. If the genus is also mentioned in the last two chapters dealing with the genera conservanda, the letter "C" is added for nomina conservanda and "(C)" for rejected genera.

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# SYNCHYTRIUM DECIPIENS AND SYNCHYTRIUM CHRYSOSPLENII

MELVILLE T. COOK

(WITH 3 FIGURES)

The material for the study of *Synchytrium decipiens* was collected in the gorges of the campus of Cornell University. The material for the study of *Synchytrium Chrysosplenii* was given to the writer by Dr. H. M. Fitzpatrick, Mycologist at Cornell University. According to the available data the host plant was *Chrysosplenium americanum* and it was collected at Labrador Lake near Ithaca, New York.

## SYNCHYTRIUM DECIPIENS (Peck) Farlow

The records indicate that this is the most widely distributed species of *Synchytrium* in America. It has been reported from Connecticut, Kansas, Massachusetts, New Jersey, New York, New Hampshire, Vermont, Pennsylvania, Maryland, North Carolina, Ohio, Indiana, Wisconsin, North Dakota, Michigan, Minnesota, Iowa, Missouri, Nebraska and Canada. It is well known as a parasite on *Amphicarpa monoica* (L.) Ell. (*Falcata comosa* Am. auth., *Glycine comosa* L.),<sup>1</sup> a host plant with very thin leaves and large intercellular spaces in the mesophyll.

The galls are small, numerous, on both surfaces of the leaves and on petioles and stems, yellow and usually surrounded by a well defined halo (FIG. 1, *A* & *B*). When the fungus is mature, the galls rupture and release the sporangia as a powder on the surfaces of the leaves. The galls are extremely variable in size and shape, depending on the location on the plant and on the age of the tissues at time of infection. Compound galls, i.e., one gall on another, are rare.

The infections are always in young, epidermal cells. They occur on both surfaces of the leaves and are most numerous in the vicinity

<sup>1</sup> It has been reported on *F. pitcheri* and *F. japonica* in Japan, on *Vigna vexillata* in Costa Rica and on *Psoralea mutisii* in Ecuador.

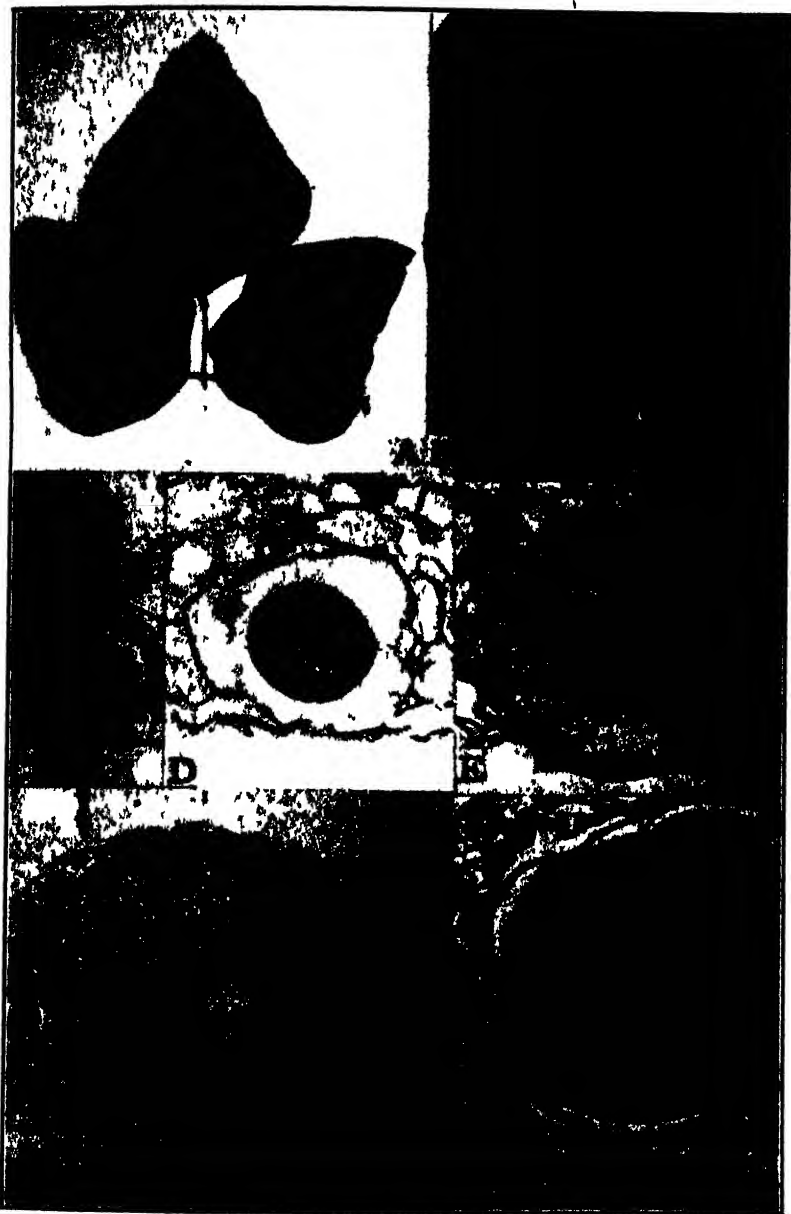


FIG. 1: *Synchytrium decipiens* on *Amphicarpa monoica*. A-B, lesions of leaf, natural size and somewhat enlarged to show halo. C-F, fungus in infected host cells in various stages of development. G, fungus showing many nuclei.

of the midribs and veins, but the age of these cells at time of infection may vary to some extent. The infected host cells enlarge rapidly and the infected area may be slightly swollen. The galls may project on one or both surfaces of the leaf and sometimes more on one side than on the other. The enlarged infected cell may be in contact with one or both epidermal layers or may be separated from one by a layer of mesophyll cells. The host cells around the infected cell divide rapidly, are small and compact and form a zone which is never as definite as the zones in other species studied by the author (FIG. 1, C-G). In fact, the fungus causes less modification of host tissue than any other species of this genus studied by the author. The thickening of the mesophyll around the infected cells on the petioles and stems is much greater than in the leaves. In some cases the host cells in contact with the infected cells are elongated (FIG. 2, D). When cells of the stems or petioles are infected, there is a pronounced thickening of the cortex and fibrovascular bundles may or may not be slightly enlarged. The epidermal cells never completely close over the infected cells, and the opening to the outside can be seen if the sections are well centered (FIG. 2, C-D). The contents of the infected host cell disintegrate and become so inconspicuous, in most cases, that they can scarcely be detected (FIG. 1, C-D). The nucleus of the infected cell disappears early and is rarely seen after infection of the cell.

The fungus does not fill the host cell until it is ready to divide into sporangia. It is dense when young, stains very deeply with age, becomes less dense and foamy as it approaches maturity (FIG. 1, C-E). In young stages, the wall surrounding the fungus can be detected in stained sections in later stages; it is always thin but well defined. The nucleus, which is not always in the center of the fungus, is rather dense when young but becomes somewhat less dense with age. Segmentation, such as reported in other species studied by the author, was not observed. Many nuclei appeared and this was followed by the formation of sporangial walls (FIG. 1, G, FIG. 2, A-C) throughout the entire fungus body. The sporangia are more numerous than in any other species studied by the author (FIG. 2, A-C). They separate and become spherical (FIG. 2, C).

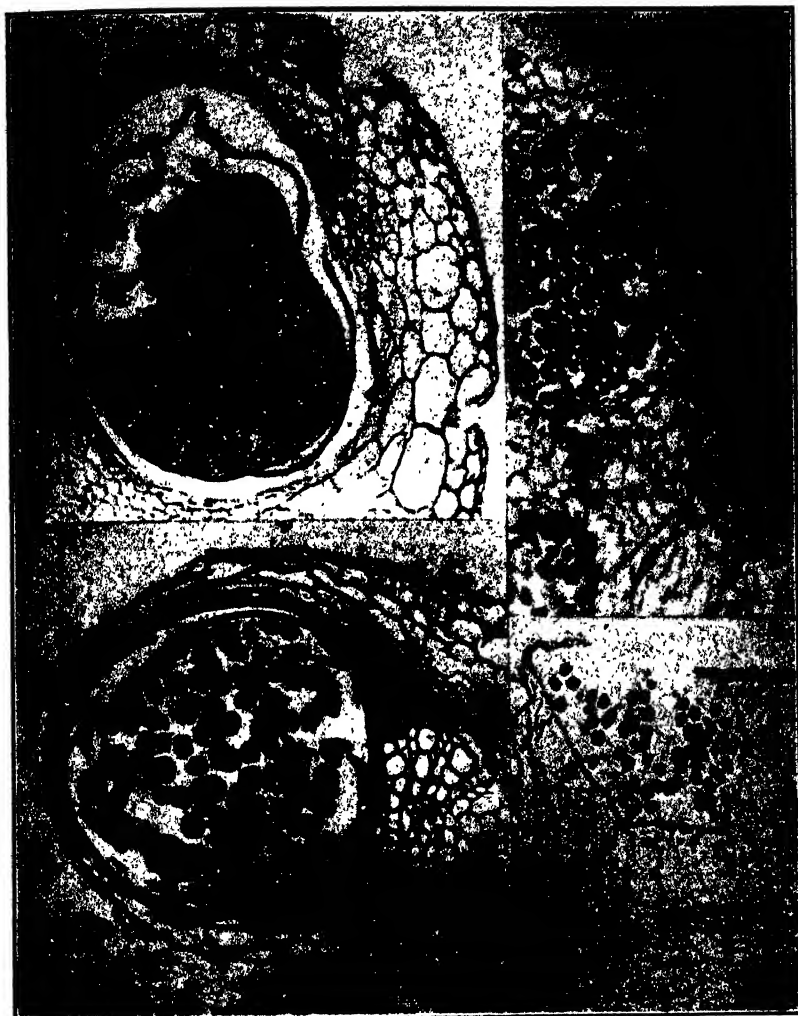


FIG. 2. *Synchytrium decipiens*. A-C, showing formation of sporangia D, sporangia surrounded by elongated host cells.





FIG 3 *Synchytrium Chrysosplenii* on *Chrysosplenium americanum*  
A-C, early stages of fungus in epidermal cells of host plant, showing large  
nucleus of host cell D, later stage showing gall and disintegrating host cell  
nucleus

## SYNCHYTRIUM CHRYSOSPENII Sorokin

Our knowledge of this species is rather limited. The infections are in the epidermal cells on both surfaces of leaves before the tissues become differentiated to form the palisade and mesophyll cells (FIG. 3, A-C). The galls vary in size regardless of age and project from either or both surfaces of the leaves. The infected cells enlarge rapidly with age and become almost spherical or pear-shaped. In some cases they lie almost midway between and in contact with the two epidermal layers. There is very little thickening of the leaves. The host cells surrounding the infected cells grow rapidly, divide and form galls which are completely or half embedded in the tissues of the leaves. The host cells which compose the submerged half of a gall are usually small, rich in protoplasm, with prominent nuclei and form a sheath of two or more layers (FIG. 3, D). The host cell nucleus is large and conspicuous. It does not show any evidence of disintegration until the fungus approaches maturity (FIG. 3, D). It is usually near the outer side of the cell (FIG. 3, A-C). It enlarges for a time and then disintegrates (FIG. 3, D). The epidermal cells grow over but never completely cover the infected cell (FIG. 3, D). The contents of the infected host cell disintegrate slowly and become foamy in appearance.

When mature, the fungus rarely fills the infected host cell but increases in size until it is about twice the diameter of the host cell nucleus. The wall around the fungus is thin. Later stages were not found in any of the material studied.

The author wishes to express his thanks to Dr. H. M. Fitzpatrick of Cornell University for material and assistance, to Dr. J. S. Karling of Columbia University for advice, to Mr. W. R. Fisher, photographer in the Department of Plant Pathology at Cornell, for photographs FIG. 1, A and B, and to Dr. C. W. Edgerton of Louisiana State University for advice and for making the photomicrographs.

DEPARTMENT OF BOTANY,  
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# STUDIES ON SOME FUNGI FROM NORTH-WESTERN WYOMING. II. FUNGI IMPERFECTI

LEWIS E. WEHMEYER<sup>1</sup>

(WITH 28 FIGURES)

In a previous paper (22), the writer has described the general region and specific localities in Wyoming from which collections were obtained during the summer of 1940. The same place names are used in this account. That paper also included a general discussion of the conclusions reached from a study of a large series of collections of fungi on the stems of a wide variety of herbaceous hosts, and described the Pyrenomycetes found thereon. The present paper is concerned with the Fungi Imperfecti which were found on these same stems, often intimately intermixed with the ascus stages. In some few cases there was some slight correlation between the ascus and conidial stages occurring on the same stems, but these were far too few to be considered as substantial proof of any genetic connection, for, as previously pointed out, these stem inhabiting forms do not seem to be limited in their host range in most cases, and many different species are commonly found growing together on one and the same stem.

## *APIOCARPELLA MACROSPORA* (Speg.) Syd. (FIG. 2)

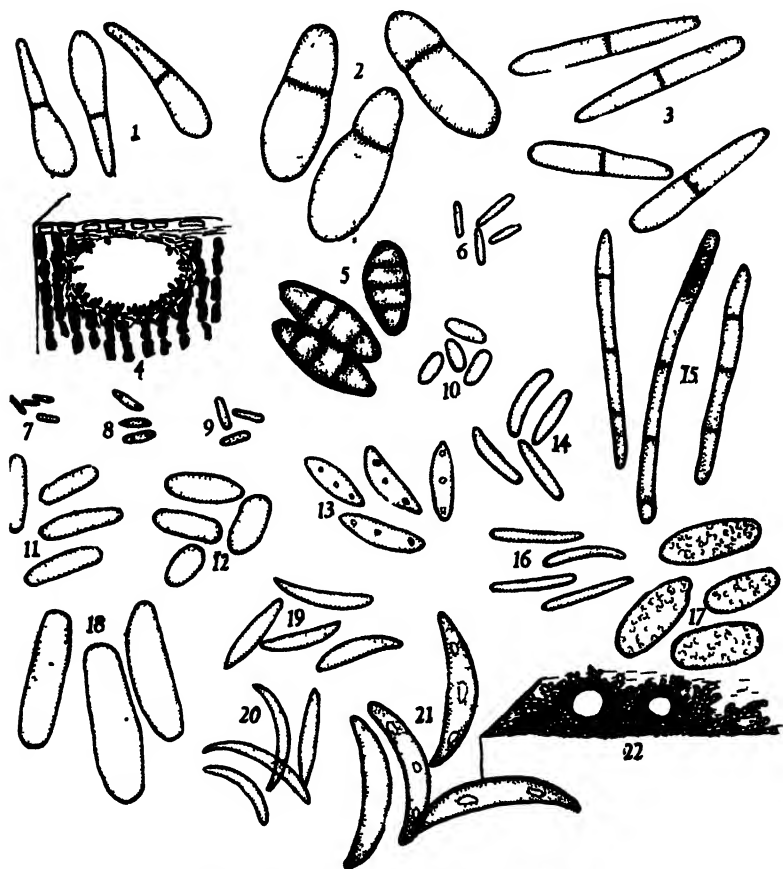
Pycnidia immersed beneath the epidermis in longitudinal rows between the veins, flattened ellipsoid,  $200-350 \times 100-150 \mu$ , membranous, walls thin, of brown-walled pseudoparenchyma, ostiole minute, papillate, erumpent through the epidermis. Conidia clavate-ellipsoid, tapered toward one end, unequally two-celled, hyaline then pale greenish brown,  $23-32 \times 8.5-10.5 \mu$ , coarsely granular, smaller cell  $9-10 \mu$  long.

Cream Puff Mt.: on leaves and leaf sheaths of an unknown grass, at 9500 ft. July 5 (1088).

Spegazzini (18, p. 364), in his descriptions of *Apiosporella macrospora* on *Hordeum jubatum* from Tierra del Fuego, gives the

<sup>1</sup> Papers from the Department of Botany of the University of Michigan, No. 765.

pycnidia as  $150\ \mu$  in diameter, and the spores as somewhat narrower ( $28\text{--}30 \times 7\text{--}8\ \mu$ ) and hyaline. This collection is placed here provisionally, for otherwise it fits Spegazzini's description very well. Inasmuch as the name *Apiosporella* was preoccupied by



FIGS. 1 22 Wyoming Fungi Imperfecti.

*Apiosporella* Hohn. (9, VIII, p. 1215), in the Pyrenomycetes, H. & P. Sydow (20, p. 43) have substituted the name *Apiocarpella* for Spegazzini's genus.

***Apiocarpella* Hedysari sp. nov. (FIG. 1)**

Pycnidia dispersa rotundata, atra, mitida, depressa vel hemisphaeroidea,  $200\text{--}300\ \mu$  diametro; ostiolo minuto, centrali; pariete tenui ex parenchymate

fuscus. Conidia elongata, attenuati-ellipsoidea, hyalina, inaequaliter bicellula, 20–23  $\mu$  longa, sursum 4.3–5  $\mu$ , deorsum 2.5  $\mu$  crassa, cellula superiore crassa rotundata, inferiore attenuata, sed aequilonga.

Specimen typicum in caulibus vetustis *Hedysari* sp., secus viam "Skyline Trail," Teton National Park, Wyoming, 24 Jul., 1940, legit L. E. Wehmeyer, sub numero 1173.

Thickly scattered as small, circular, shiny, black spots, consisting of the strongly erumpent, flattened to hemispheric pycnidia, 200–300  $\mu$  in diameter, with a minute central ostiole and a rather thin membranous wall of brown pseudoparenchyma. Conidia elongate tapered-ellipsoid, hyaline, with two unequal cells, the upper broader and rounded, the lower narrower and tapered, but about equal in length, 20–23  $\times$  4.3–5  $\mu$  above, 2.5  $\mu$  in diameter below.

Skyline Trail: July 24, on *Hedysarum* sp. (1173) (Type).

S. of Teton Pass: July 11, on *Hedysarum uintahense* A. Nels. (1126g).

These spores are narrower and the cells more nearly equal in length than those of *A. macrospora*. They are much more tapered and unequally two-celled than in *Diplodina*. On No. 1173 these pycnidia are associated with *Apiosporella alpina* and on No. 1126g with *Sphaerulina inaequalis*, but a number of other fungi occur on the same stems in both cases.

#### CERCOSPORA GALII Ell. & Holw.

Forming irregular, gray-brown necrotic areas, 0.5–1 cm. in diameter upon the leaves. On the under side of these areas there are numerous, evenly scattered, black spots, which appear like pycnidia, but prove to be erumpent tuberculate masses of brown hyphae bearing on their surface numerous, lighter colored, short, stout conidiophores, 9–15  $\times$  2.5  $\mu$ . These stromatic acervuli are 50–70  $\mu$  in diameter. The conidia are long cylindric, straight or slightly curved, with the attached end rather blunt, and the free end more acute, one-celled, hyaline, guttulate, 35–40  $\times$  2.5–3.5  $\mu$ .

Hoback Canyon: July 8, on *Galium triflorum* Michx., Red Creek (1162).

This appears more like a *Cylindrosporium*, but seems to fit the description of *Cercospora Galii*.

#### CONIOTHYRIUM SAMBUCCI Earle

Pycnidia rather widely scattered, sometimes confluent, formed beneath the epidermis, but soon erumpent, superficial, globose, with

a flattened base, 200–350  $\mu$  in diameter, walls of coarse black pseudoparenchyma. Conidia globose to subglobose,  $6-7.5 \times 6 \mu$ .

S. of Teton Pass: July 11, on *Sambucus microbotrys* Rydb. (1133a).

Associated with *Steganosporium tuberculiforme*.

### **Cylindrosporium Fraserae** sp. nov.

Maculae emortuae, circulares vel ellipticae, grisei-brunneae; margine irregulari, atro, incrassato. Stromata minuta, atra, sterilia, lineae marginali similia, in maculas dispersa. Acervuli epiphylli, concolores, in folii contexto immersi, globosi, 100  $\mu$  diametro, plerumque de causa conidiorum abscissione modice concavi, hyphis hyalinis. Conidia numerosa, elongata, filiformia, unicellula, 65–70  $\mu$  longa, 2–2.5  $\mu$  crassa.

Specimen typicum in foliis *Fraserae speciosae* Griseb., prope Camp Davis, Jackson, Wyoming, 7 Jul., 1940, legit L. E. Wehmeyer, sub numero 1094.

On surface of leaf as scattered, circular or elliptic, gray-brown, necrotic areas,  $3-10 \times 2-5$  mm., bounded by an irregular, finally blackened, raised margin. There are irregular blackened spots in these areas, which when sectioned prove to be sterile stromatic areas similar to the marginal zones. The fruiting structures appear as minute concolorous papillae on the upper surface of the spot. These fruit bodies originate as globose to ellipsoid masses of hyaline interwoven hyphae, some 100  $\mu$  in diameter, within the leaf tissue. Numerous elongate, filiform, one-celled, hyaline conidia,  $65-70 \times 2-2.5 \mu$ , are cut off from the surface of this "acervulus," which becomes somewhat concave as a result of this spore formation.

Camp Davis: on *Fraseria speciosa* Griseb., July 7 (1094) (Type).

The globose mass of hyphae formed within the leaf gives the fungus the appearance of a *Phlecospora*, but the conidia are cut off from the surface of this stroma where it breaks through the epidermis thus placing it, rather, in *Cylindrosporium*.

### **CYLINDROSPORIUM SPIRAEICOLUM** E. & E.

Hoback Canyon: Red Creek, July 18, on *Spiraea lucida* Dougl. (1160).

Cascade Canyon: on *Spiraea densiflora* Nutt., June 27 (1091).

Ellis (6, p. 429) gives this species as forming minute yellow spots, 1–2 mm. in diameter and having clavate, 3–5-septate spores,

40–70  $\times$  3.5–5  $\mu$ . This collection shows larger (3–6 mm.) pale red brown spots and guttulate but not septate spores measuring 74–107  $\times$  2.5–3.5  $\mu$ . Solheim (17, 3, p. 41), however, reports spores of this species, from this same region, as being one- or non-septate and 40–108  $\times$  3–4.5  $\mu$ . The clavate form of the spore is also distinctive.

A second collection on *Spiraea densiflora* Nutt., from Cascade Canyon, Teton Nat. Park, June 27, shows more sharply margined angular spots and resinous spore masses resembling rust pustules, with spores 2- to 3-septate and 53–88  $\times$  3.5  $\mu$ .

#### CYLINDROSPORIUM CONSOCIATUM Dearn.

Spores long filiform, with pointed ends, 3–4-septate, 43–62  $\times$  1.5  $\mu$ .

Hoback Canyon: July 17, on *Acer glabrum* Torr. (1155).

#### DIPLODIA CLEMATIDEA Sacc.

Pycnidia 250–350  $\mu$  in diameter, globose or somewhat depressed, granular, scattered or in seriate groups, often confluent, formed beneath the epidermis, then erumpent, ostiole small, papillate. Conidia oblong-ellipsoid, two-celled (rarely three-celled), not or only slightly constricted at the septum, ends rounded, brown, 10.5–14  $\times$  5–6  $\mu$ .

S. of Teton Pass: July 11, on *Clematis Douglassii* Hook. (1124c and 1131a).

Although brief, and made from material from South Africa on *Clematis brachiata*, the description of *D. clematidea* Sacc. (*S. Clematidis* Kalch. & Cke., non Sacc.) fits this material very well. Both collections, made within a quarter of a mile of one another, were associated with *Mycosphaerella dolichospora*, and several other fungi.

#### DIPLODIA POLYGONICOLA Pk.

Pycnidia small, 150–200  $\mu$  in diameter, irregularly scattered, immersed, then erumpent, borne on a more or less well developed system of torulose mycelium. Conidia oblong to broad ellipsoid, two-celled, brown, not constricted at the septum, 12.5–16  $\times$  7–9  $\mu$ .

Camp Davis: June 22, on *Castilleja flava* Wats. (1036).

There are a number of species of *Diplodia* described with similar spores, but none on related hosts. The nearest seems to be *D. polygonicola* Pk., from Kansas, with minute pycnidia and spores  $14-16 \times 8-9 \mu$ .

***Diplodina attenuata* sp. nov. (FIG. 3)**

Pycnidia  $300-400 \mu$  diametro,  $150-200 \mu$  alta, dense et aequaliter per latas areas caulis dispersa, sub epidermate formata sed in superficie ut maculae parvae, rotundae, atrae, cum ostiolo centrali papilliformi manifesta, admodum depressa; pariete crasse parenchymatico. Conidia cylindrica, bicellula, hyalina,  $23-32 \mu$  longa,  $4-5.5 \mu$  crassa, ad apicem attenuata, guttulata.

Specimen typicum in caulibus vetustis Compositarum (*Helianthellae?*), prope Togwotee Pass, Teton Co., Wyoming, 8 Jul., 1940, legit L. E. Wehmeyer, sub numero 1100d.

Pycnidia rather thickly and evenly scattered over extended areas of the stem,  $300-400 \times 150-200 \mu$ , formed beneath the epidermis, but visible on the surface as small circular blackened spots with a central papillate ostiole, strongly flattened, with thick walls of coarse black pseudoparenchyma. Conidia cylindric, straight, usually somewhat tapered toward one end, two-celled, hyaline, with several small guttulae,  $23-32 \times 4-5.5 \mu$ .

Togwotee Pass: July 8, on some Composite (*Helianthella?*) (1100d) (Type).

These spores are much less strongly tapered than in *Apiocarpella Helysari*. Scattered pycnidia of a very similar *Diplodina*, with somewhat tapered spores  $19.5-26 \times 4-5 \mu$ , were found mixed in with *Pleospora permunda*, on stems of an unknown Composite, from Glory Mt. (1024d).

**DIPLODINA FRASERAE (E. & E.) Tracy & Earle**

Pycnidia thickly scattered on rather extensive, somewhat discolored areas of the stem or leaf bases,  $100-300 \mu$  in diameter, globose, black, erumpent as a minute ostiole and with a wall of black compacted hyphae. Conidiophores short, bearing oblong-cylindric, straight to slightly curved, two-celled, hyaline conidia,  $16-21 \times 3-5 \mu$ .

Glory Mt.: June 20, on *Frasera speciosa* Griseb. (1027).

Ellis (5, p. 289) described *Ascochyta Fraseriae*, from Colorado, as having pycnidia  $80-100 \mu$  in diameter and spores  $12-15 \times 4-5 \mu$ .



It was later transferred to *Diplodina* by Tracy & Earle. In 1920, Saccardo (Nuov. Giorn. bot. ital. n. s. 27: 82) described a second *Ascochyta Fraserae* from Spokane, Washington, as having lenticular pycnidia, 150–160  $\mu$  in diameter and spores  $21-23 \times 4.5-5 \mu$ . This collection comes closer to Saccardo's description, but his name is preoccupied by that of Ellis, if Ellis' species is a distinct one. It seems probable, however, that Ellis merely had immature material and that these are all the same species, for the spores are quite variable in size. The pycnidia occur upon both leaves and stems, so the generic difference between *Diplodina* and *Ascochyta* breaks down. Inasmuch as the pycnidial wall is rather coarse and stromatic, and the fungus occurs primarily on stems, the *Diplodina* binomial is used.

***Hendersonia pinicola* sp. nov. (FIGS. 4–5)**

Pycnidia globosa, 100–150  $\mu$  diametro, intra mesophyllium folii Pini immersa; ostiolo minuto; pariete prosenchymatico, cum cellulis mesophyllii admixtis. Conidia fusiformiter ellipsoidea vel clavata, fusca, primum unicellula, deinde 4-cellula, ad septa haud constricta, 14–20  $\mu$  longa, 5–7  $\mu$  crassa, in foliorum superficie in maculis atris aggregata.

Specimen typicum in foliis *Pini Murrayanae*, prope Camp Davis, Jackson, Wyoming, 17 Jun., 1940, legit L. E. Wehmeyer, sub numero 1004a.

Appearing on the living needles as small irregular, black, paint-like masses of conidia, emitted from globose pycnidia, 100–150  $\mu$  in diameter, entirely immersed in the leaf mesophyll and opening by a minute pore. Wall of pycnidium consisting of merely the subhymenial prosenchyma and a few imbedded host cells. Conidiophores short, 5–6  $\mu$  in diameter. Conidia fusoid-ellipsoid to clavate, brown, one-celled at first, becoming four-celled, not constricted at the septa,  $14-20 \times 5-7 \mu$ .

Camp Davis: June 17, on living needles of *Pinus Murrayana* Balf., leg. L. E. Wehmeyer (1004a) (Type).

*Hendersonia acicola* Münch. & Tub., with somewhat smaller spores ( $11-15 \times 4-5 \mu$ ), is very similar to this collection. Lagerberg's figures (12, figs. 6 & 7) of *H. acicola* are characteristic of this collection, except for the greater constriction at the septa in his figures. This collection is kept as a separate species because of the additional fact that it is found associated with *Hypodermella concolor* in much the same manner as *Hendersonia acicola* has been found associated with *Hypodermella sulcigena* (12).

## HETEROPATELLA UMBILICATA (Pers.) Jaap

Pycnidia usually rather widely scattered,  $200-600 \times 150-200 \mu$ , depressed spheric, formed beneath the epidermis but soon erumpent-superficial, often with fragments of this tissue adhering, soon strongly pezizoid collapsed. Walls membranous, thin, composed of small dark-walled pseudoparenchyma cells which are arranged in a radiate and "asterinoid" manner about the central ostiole which splits radially to release the spore content. Conidia hyaline, long fusoid, lunate, curved, with a tapered base where attached and at the apex a long filiform appendage up to  $28 \mu$  in length, bi-septate when mature, but often with only one or no septum visible, with several small droplets on each side of the septum,  $18-22 \times 1.5-2.5 \mu$ , without the appendage.

S. of Teton Pass: July 11, on *Hedysarum uintahense* A. Nels. (1126); *Aquilegia coerulea* James (1114b); *Carum Carui* L. (1132b); *Agastache urticifolia* (Benth.) Rydb. (1121c); *Linum Lewisii* Pursh (1134g); *Pedicularis contorta* Benth. (1135b) and *Delphinium Brownii* Rydb. (1129e).

Glory Mt.: June 20, on *Cynomarathrum Parryi* (S. Wats.) Coult. & Rose (1028a).

Togwotee Pass: July 8, on *Myosotis alpestris* Schmidt (1213) and *Helianthella* sp. (?) (1100).

Skyline Trail: July 24, on *Carum Carui* L. (1166g) and *Aconitum Bakeri* Greene (1169c).

The proper binomial for this fungus is an open question. It was described from the arctic and subarctic, as *Septoria cercosperma*, by Rostrup (15, p. 41), and from Beeren Island, as *S. caudata*, by Karsten (11, p. 38), both of which were transferred to *Rhabdospora* by Saccardo. In 1885, Ellis & Everhart (3, p. 153) erected the genus *Kellermania* for such pycnidial forms with appendaged spores, and his *K. alpina* (7, p. 57), on *Aquilegia*, from the mountains of Colorado, is no doubt this fungus. In 1910, Lind (13, p. 159) made the combination *Kellermania cercosperma* and suggested that *K. yuccagena* E. & E., *K. polygoni* E. & E., *K. Sisyrinchii* E. & E., and *K. Rumicis* Fautr. & Lamb. might all be the same species. The recorded measurements of spores for these species of *Kellermania* vary from  $15-18 \times 4$  to  $45-50 \times 10-12 \mu$ , but the larger measurements include the length of the appendage,

which is quite variable. In 1923, this same fungus was reported as *Discosia acuta* Dearn. by Dearness (2, p. 18) from northern Canada. In 1926, Lind (14, p. 170) stated that *Heteropatella umbilicata* (Pers.) Jaap from the Swiss Alps is this same fungus and gives its synonymy in which only *Kellermania cercosperma* and *K. Rumicis*, of the above mentioned species of this genus, are included. The flattened pycnidium and the radiate cell arrangement of the upper wall, with the radiate splitting about the ostiole, would no doubt allow this fungus to be placed in *Heteropatella*, in which case *Kellermania* would be a synonym of that genus. *Heteropatella* was originally described as having one-celled spores, but these have been found to become septate. Grove (8, v. 2, p. 159) lists several of these synonyms as doubtfully in the genus *Heteropatella*, and Sprague and Cooke (19, p. 48) have reported this species under the name of *Heteropatella alpina* (E. & E.) W. B. Cooke, which should be a synonym. As pointed out by Lind (14, p. 170), *Heteropatella* has been considered the conidial stage of species of *Heterosphaeria*. In the Wyoming material, it was found associated with many different pyrenomycetous fungi, but no associated *Heterosphaeria* was found in any case.

Whatever the proper name may be, this is one of our most widespread arctic-alpine forms and is reported upon in nearly all the floras of such regions. In Wyoming, the twelve collections were taken from four stations, all of which have an elevation of 9000 feet or more.

***Leptostroma Lupini* sp. nov. (FIG. 6)**

Pycnidia depressa, 250–400  $\mu$  diametro, 70–100  $\mu$  alta, dense dispersa vel confluentia, primum subepidermalia, deinde superficialia, in superficie caulis ut maculae irregulares vel elliptices, 250–1000  $\mu$  longae evidenter, superficialiter corrugata, per rimam unam (vel plures) efferentia; pariete prosenchymatoso, sursum atribrunneo, 10–15  $\mu$  crasso, deorsum discolori. Conidia cylindrica, bacilliformia, unicellula, hyalina, 9–10.5  $\mu$  longa, 1.5–2  $\mu$  crassa, ex conidiophoris brevibus.

Specimen typicum in caulibus *Lupini candicantis* Rydb., prope locum dictum "Togwotee Pass," Teton County, Wyoming, 8 Jul., 1940, legit L. E. Wehmeyer, sub numero 1101b.

Pycnidia on surface as more or less scattered or confluent, elliptic to irregularly flattened, black spots, 250–1000  $\mu$  long with a wrinkled surface and opening by one or several elongate slits.

They are subepidermal, but the epidermis soon disappears, leaving them superficial. Pycnidia flattened,  $250-400 \times 70-100 \mu$ , outer walls of dark brown prosenchyma,  $10-15 \mu$  thick, basal wall of discolored host tissue. Conidiophores short, bearing cylindric, bacillar, one-celled, hyaline conidia,  $9-10.5 \times 1.5-2 \mu$ .

Togwotee Pass: July 8, on *Lupinus candicans* Rydb. (1101b) (Type); and *Lupinus* (*parviflorus*?) (1103a).

**Pellionella tetonensis** sp. nov. (FIGS. 25-26)

Pycnidia superficialia, dense dispersa vel aggregata, globosa, carbonacea, atra,  $300-500 \mu$  diametro; collo cylindrico, elongato,  $400-500 \mu$  longo; pariete  $40-50 \mu$  crasso, bistrato, extus crasso, atro, intus tenui, hyalino, parenchymatoso. Conidia cylindrica vel oblongi-ellipsoidea, bicellula, non constricta,  $8-9 \mu$  longa,  $2.5 \mu$  crassa, primum hyalina deinde fusca, abscissa ex conidiophoris in pariete pycnidiorum interiore.

Specimen typicum in caulibus vetustis *Lupini parviflori* Nutt., prope Teton Pass, Jackson, Wyoming, 11 Jul., 1940, legit L. E. Wehmeyer, sub numero 1110b.

Appearing on the surface as crowded or clustered, superficial, globose, carbonaceous, black pycnidia,  $300-500 \mu$  in diameter, with an elongate, cylindric, ostiolar neck,  $400-500 \mu$  in length. Pycnidial wall  $40-50 \mu$  thick, consisting of an outer layer of thick, black-walled, and a thinner, inner, hyaline-walled pseudoparenchyma. Wall lined with short conidiophores bearing the cylindric, oblong-ellipsoid, two-celled, non-constricted conidia, which are hyaline at first but soon become brown and  $8-9 \times 2.5 \mu$ .

S. of Teton Pass: July 11, on *Lupinus parviflorus* Nutt., leg. L. E. Wehmeyer (1110b) (Type).

The superficial position of these pycnidia is that of the form genus *Diplodiella*, but the elongate ostiolar necks place them in *Pellionella*. No species with these large pycnidia and small spores could be found in either of these genera.

**Phaeoseptoria Scirpi** sp. nov. (FIG. 15)

Pycnidia late sed aequaliter dispersa,  $100-150 \mu$  diametro, in contextum caulis immersa, erumpentia ut puncta minuta, atra; pariete  $5-10 \mu$  crasso, atro, parenchymatico. Conidia longe cylindric-filiformia, modice curvata,  $38-46$  longa,  $2-3 \mu$  crassa, saepe triseptata vel intus 4-partita, prope septa guttulatula, pallide lutea, communiter lutei-brunnea.

Specimen typicum in culmis *Scirpi validi* Vahl, ad Elk Refuge, Jackson, Wyoming, 1 Jul., 1940, legit L. E. Wehmeyer, sub numero 1071b.

Pycnidia widely but evenly scattered, immersed in the stem tissue, 100–150  $\mu$  in diameter, erumpent as minute black spots, wall 5–10  $\mu$  thick, of dark colored pseudoparenchyma. Conidia long cylindric-filiform, somewhat curved, often triseptate, or with a four-parted protoplast, with minute droplets near the partitions, pale yellow in color, yellow-brown in mass,  $38\text{--}46 \times 2\text{--}3 \mu$ .

Elk Refuge, Jackson, Wyo.: on *Scirpus validus* Vahl, July 1, leg. L. E. Wehmeyer (1071b) (Type).

This species was found associated with *Metasphaeria juncinella* (1071a) and might be its conidial stage. The colored conidia place it in *Phaeoseptoria*. Similar species are *Septoria Scirpi* Sacc. with similar but hyaline spores and *S. narvisiana* Sacc. with dilute olive, but 5–7-septate spores.

#### PHOMA

The taxonomic situation in the genus *Phoma* is similar to that mentioned under *Mycosphaerella* (22). So many species of similar morphology have been described upon the basis of host differences, that this means of distinction is practically forced upon one, even though it seems probable that a species may not be limited in its host range. In Table I, the collections of *Phoma* and *Macrophoma* are arranged according to their spore measurements, and more or less arbitrarily divided into species as indicated by the lines of separation.

#### *Phoma bacilliformis* sp. nov. (FIG. 7)

Pycnidia dense dispersa, in areis obscuris caulium *Senecionis*, 200–300  $\mu$  diametro, immersa; ostiolo brevi cylindrico, per epidermatem erumpente; pariete tenui, 10–20  $\mu$  crasso, in aetate modice collapsa. Conidia brevina, cylindrica, bacilliformia, hyalina, 2–3  $\mu$  longa, 0.8–1  $\mu$  crassa.

Specimen typicum in caulibus vetustis *Senecionis*, secus viam "Skyline Trail," Teton National Park, Wyoming, 24 Jul., 1940, legit L. E. Wehmeyer, sub numero 1177b.

Pycnidia thickly scattered on somewhat discolored areas of the stem, flattened spheric, 200–300  $\mu$  in diameter, immersed, erumpent through the epidermis as short, prominent, cylindric ostioles, thin-walled (10–20  $\mu$ ), collapsing somewhat in age. Conidia short, cylindric, bacilliform, hyaline,  $2\text{--}3 \times 0.8\text{--}1 \mu$ .

TABLE I

No.	Host	Spore Range	Pycnidia
1177b	SENECIO	2-3×0.8-1	200-350
1075	LACTUCA	3.5-4×1-1.5	70-100
1086c	PENSTEMON	3.5-4.5×1-2	150-250
1185d	DRABA	3.5-5.5×1-2	200-250
1074	POLEMONIUM	4-5.5×2.5-3	200-300
1065b	LUPINUS	4-7×2.5-3.5	200-350
1095a	PEDICULARIS	7-11×1.5-2	200-250
1097b	PEDICULARIS	7-11×1.5-2	200-250
1035a	PEDICULARIS	(6) 7-9×2-2.5	200-400
1032b	SYNTHESIS	7-10.5×2-2.5	200-250
1109c	AGASTACHE	7-9×2.5-3.5	200-300
1128c	VALERIANA	8.5-9.5×2.5	200-300
1055b	SPHAERALCEA	9-11 (13)×2.5-3.5	200-300
1090	LINUM	9-15×2.5-3.5	100-150
1211a	GILLIA	10-14×1.5-2	200-300
1022b	UMBELLIFER	10-14×1.5	350-500
1113c	ERIGERON	12.5-14×2-2.5	100-150
1016c	PENSTEMON	12-15×5-6	150-250
1171a	MIMULUS	18-26×5-6.5	200-250

Skyline Trail: July 24, on *Senecio* sp. (1177b) (Type).

This collection differs from all of the others in the very small spores.

### ***Phoma pulchellicola* sp. nov. (FIG. 8)**

Pycnidia in areis mycelii atrifuscis, dense septatis superficialis reptantis dispersa; subepidermalia, parva, 70-100  $\mu$  diametentia, atribrunnea, poro uno perforata; hyphis superficialibus saepe lateraliter in ligulis unitis. Conidia minuta, fusiformia, eseptata, hyalina, biguttulata, 3-5  $\mu$  longa, 1-1.5  $\mu$  crassa.

Specimen typicum in caulibus vetustis *Lactucac pulchellae* (Pursh) DC., prope Snake River, Jackson, Wyoming, 11 Jul., 1940, legit L. E. Wehmeyer, sub numero 1075.

Pycnidia on small blackened areas caused by a rich dark brown, closely septate, creeping, superficial mycelium, with the hyphae often united into ribbon-like strands. Pycnidia subepidermal, small, 70-100  $\mu$  in diameter, dark brown, with a pore-like opening.

Conidia minute, fusoid, one-celled, hyaline,  $3.5-4 \times 1-1.5 \mu$ , with a small guttula in each end.

On *Lactuca pulchella* (Pursh) DC., Snake River, Jackson, Wyo., July 11, 1940, leg. L. E. Wehmeyer (1075) (Type).

The spores and pycnidia of this collection are similar to those given for *Phyllosticta decidua* Ell. & Kell., which has been reported from many hosts including *Lactuca*, from Wisconsin, by J. J. Davis. Tehon (21, p. 245), however, describes a new species *Phyllosticta scariolicola*, on the basis of its occurrence upon a separate host species of *Lactuca*, and states that the differences of host limitation and ascus stage association in the *decidua* group make this advisable. If such theoretical differences are used in the separation of species, it forces one to describe this species as new because of its different specific host or monograph the group in order to find its proper position.

**Phoma jejuna** sp. nov. (FIG. 9)

Pycnidia distanter vel dense dispersa, paulo depressa,  $150-300 \mu$  diametro, pariete tenui. Conidia breviter cylindrica, unicellula, bacilliformia, hyalina,  $3.5-5.5 \mu$  longa,  $1-2 \mu$  crassa.

Specimen typicum in caulibus vetustis *Penstemonis stenosepalus* (Gray) Howell, in loco dicto "Cream Puff Mt.," Jackson, Wyoming, 5 Jul., 1940, legit L. E. Wehmeyer, sub numero 1086c.

Pycnidia widely or thickly scattered, somewhat depressed-spheric, thin-walled,  $150-300 \mu$  in diameter. Conidia oblong-cylindric, bacillar, one-celled, hyaline,  $3.5-5.5 \times 1-2 \mu$ .

Cream Puff Mt.: July 5, on *Penstemon stenosepalus* (Gray) Howell, leg. L. E. Wehmeyer (1086c) (Type).

Hoback Canyon: Red Creek, July 29, on *Draba luteola* Greene (1185d).

*Phyllosticta Pentastemonis* Cke., the only species described on these hosts, which approaches these collections, has spores which are oblong-ovoid to ellipsoid and  $5 \times 3 \mu$ , which are more like those of the following species with broader spores.

**Phoma minuta** sp. nov. (FIG. 10)

Pycnidia dense dispersa, depressiuscule globosa,  $200-350 \mu$  diametro; ostiolo papilliformi, centrali. Conidia cylindrica vel breviter ellipsoidea, unicellula, hyalina,  $4-6 (7) \mu$  longa,  $2-3 \mu$  crassa.

Specimen typicum in caulibus vetustis *Polemonii occidentalis*, ad Elk Refuge, Jackson, Wyoming, 1 Jul., 1940, legit L. E. Wehmeyer, sub numero 1074.

Pycnidia thickly scattered, somewhat depressed spheric, with a central papillate ostiole, 200–350  $\mu$  in diameter. Conidia one-celled, hyaline, cylindric to oblong-ellipsoid, 4–6 (7)  $\times$  2–3  $\mu$ .

Elk Refuge, Jackson, Wyo.: on *Polemonium occidentale* Greene, July 1, leg. L. E. Wehmeyer (1074) (Type).

Camp Davis: June 26, on *Lupinus parviflorus* Nutt. (1065b).

No similar species seems to be described on either of these hosts. This species resembles the last except for the broader spores.

#### **Phoma Pedicularis** sp. nov. (FIG. 14)

Pycnidia dispersa, depresso globosa, 200–250  $\mu$  diametro, in cellulas sub-epidermales immersa. Conidia cylindrica, recta vel paulum curvata, hyalina, 7–11.5  $\mu$  longa, 1.5–2  $\mu$  crassa.

Specimen typicum in caulibus vetustis *Pedicularis bracteosa* Benth., prope Togwotee Pass, Teton Co., Wyoming, 8 Jul., 1940, legit L. E. Wehmeyer, sub numero 1095a.

Pycnidia scattered, depressed-spheric, 200–250  $\mu$  diameter, immersed beneath the epidermis. Conidia cylindric, straight or slightly curved, one-celled, hyaline, 7–11.5  $\times$  1.5–2  $\mu$ .

Togwotee Pass: July 8, on *Pedicularis bracteosa* Benth., leg. L. E. Wehmeyer (1095a) (Type), and *P. racemosa* Dougl. (1097b).

This species is similar to *P. herbicola* and *P. herbarum*, but has narrower spores than either. It is also similar to *P. montenegrina* Bub., but has larger pycnidia. Both collections were found in association with *Apiospora alpina*.

#### **Phoma herbicola** sp. nov. (FIG. 11)

Pycnidia dispersa vel aggregata, sub epidermate immersa, deinde superficialia, depressiuscule globosa, 200–400  $\mu$  diametro; ostiolo centrali, perforato; pariete crasso, ex parenchymate crasso, atro. Conidia cylindrica vel subellipsoidalia, continua, hyalina, (5.5) 7–10.5  $\mu$  longa, 2–2.5  $\mu$  crassa.

Specimen typicum in caulibus vetustis *Syntheris dissectae* Rydb., in monte dictu, "Glory Mountain," Jackson, Wyoming, 20 Jul., 1940, legit L. E. Wehmeyer, sub numero 1032b.

Pycnidia scattered or grouped, sub-epidermal, becoming erumpent, somewhat depressed-spheric, 200–400  $\mu$  in diameter, with a



central pore-like ostiole and thick walls (40–50  $\mu$ ) of coarse dark pseudoparenchyma. Conidia cylindric to cylindric-ellipsoid, one-celled, hyaline, (5.5) 7–10.5  $\times$  2–2.5  $\mu$ .

Glory Mt.: June 20, on *Syntheris dissecta* Rydb., leg. L. E. Wehmeyer (1032b) (Type).

Teton Pass Rd.: June 20, on *Pedicularis bracteosa* Benth. (1035a).

These collections are very similar to those given under *P. herbarum*, but the conidia are somewhat narrower and more cylindric. *P. coloradensis* Earle, on *Pedicularis*, is given with spores 8–10  $\times$  3–4  $\mu$ , which are more like those of *P. herbarum*.

#### PHOMA HERBARUM West.

Pycnidia rather widely scattered, just beneath the epidermis, slightly depressed globose, 200–300  $\mu$  in diameter, with a central papillate ostiole. Conidia cylindric to cylindric-ellipsoid, one-celled, hyaline, 7–11  $\times$  2.5–3.5  $\mu$ .

Hoback Forest Camp: June 25, on *Sphaeralcea rivularis* (Dougl.) Torr. (1055b).

S. of Teton Pass: July 11, on *Valeriana* sp. (1128c) and *Agastache urticifolia* (Benth.) Rydb. (1109c).

*Phoma herbarum* and its many varieties on various herbaceous stems are given as having spores 6–11  $\times$  3–4  $\mu$ . These collections seem to fit it most closely. The variety on *Valeriana* is given by Saccardo (Syll. Fung. 3: 133) as having spores 6  $\times$  3.5  $\mu$ . The collection on *Agastache* is similar to *P. Lophanthi* Bub., but that species has narrower spores (1.5–2  $\mu$ ). On *Sphaeralcea* the spores (9–11–13  $\mu$ ) are somewhat longer than on the other hosts (7–9  $\mu$ ).

#### *Phoma fusispora* sp. nov. (FIG. 13)

Pycnidia dense dispersa, 100–150  $\mu$  diametro, depresso globosa, in maculis griseis cum hyphis reptantibus, fuscis, superficialibus; ostiolo perforato, deinde late fisso, ultimum basi cupuliforme. Conidia fusiformia vel fusiformiter ellipsoidalia, continua, hyalina, 9–15  $\mu$  longa, 2.5–3.5  $\mu$  crassa.

Specimen typicum in caulibus vetustis *Lini Lewisii* Pursh, in monte dictu, "Cream Puff Mountain," Jackson, Wyoming, 5 Jul., 1940, legit L. E. Wehmeyer, sub numero 1090.

Pycnidia thickly scattered, with a certain amount of creeping brown surface mycelium, giving the infected areas a somewhat grayish discolored appearance, depressed-globose, 100–150  $\mu$  in diameter, ostiolar opening at first perforate, then somewhat elongate and finally widely ruptured, leaving only the cup shaped base of the pycnidium. Conidia fusoid to fusoid-ellipsoid, one-celled, hyaline,  $9\text{--}15 \times 2.5\text{--}3.5 \mu$ .

Cream Puff Mt.: July 5, on *Linum Lewisii* Pursh, legit L. E. Wehmeyer (1090) (Type).

This differs from the *P. herbarum* collections in the longer, more fusoid spores and the surface hyphal growth. *P. linicola* Buh. has curved allantoid spores  $7\text{--}11 \times 2.5\text{--}3.5 \mu$ .

### **Phoma linearispora** sp. nov. (FIG. 16)

Pycnidia dense sub epidermate paulum discolore dispersa, circumscriptione rotunda vel elliptica,  $300\text{--}500 \times 200\text{--}350 \mu$ , depresso globosa; ostiolo cylindrico, papilliformi vel paulum elongato, erumpente; pariete  $20\text{--}30 \mu$  crasso, parenchymatoso, parvicellulo, atrimembranoso. Conidia longe cylindrica, continua, hyalina, recta vel paulum curvata, 4-guttulata, interdum subconstricta,  $10\text{--}14 \mu$  longa,  $1.5\text{--}2 \mu$  crassa.

Specimen typicum in caulibus vetustis plantarum Umbelliferarum, prope Teton Pass, Jackson, Wyoming, 20 Jun., 1940, legit L. E. Wehmeyer, sub numero 1022b.

Pycnidia rather thickly scattered, circular to elliptic in outline,  $300\text{--}500 \times 200\text{--}350 \mu$ , immersed beneath the slightly discolored epidermis, flattened-spheric and erumpent as a papillate to slightly elongate, cylindric ostiole, wall  $20\text{--}30 \mu$  thick, of small dark walled pseudoparenchyma. Conidia long-cylindric, one-celled, hyaline, straight to slightly curved, with four or more small droplets and sometimes with the suggestion of a central constriction,  $10\text{--}14 \times 1.5\text{--}2 \mu$ .

S. of Teton Pass: June 20, on *Umbellifer* stems (1022b) (Type) and *Gillia Watsonii* Gray (1211a).

### **Phoma wyomingensis** sp. nov. (FIG. 17)

Pycnidia dense dispersa,  $150\text{--}250 \mu$  diametro, aspera, globosa, vel depressa, erumpentia, deinde superficialia; ostiolo centrali, papilliformi; pariete  $20\text{--}40 \mu$  crasso, atro, crasse parenchymatoso. Conidia cylindrica, unicellula, hyalina, crasse granulosa,  $12\text{--}15 \mu$  longa,  $5\text{--}6 \mu$  crassa, in conidiophoris crassis.

Specimen typicum in caulibus vetustis *Penstemonis glabrae* Pursh, prope Camp Davis, Jackson, Wyoming, 18 Jul., 1940, legit L. E. Wehmeyer, sub numero 1061c.

Pycnidia thickly scattered, rough, black, erumpent-superficial, globose to flattened,  $150\text{--}250\ \mu$  in diameter, with a central, papillate ostiole and a thick ( $20\text{--}40\ \mu$ ) wall of very black, thick-walled pseudoparenchyma. Conidia cylindric-oblong, one-celled, hyaline, with a coarsely granular cytoplasm,  $12\text{--}15 \times 5\text{--}6\ \mu$ , borne on short conidiophores.

Camp Davis: June 18, on *Penstemon glaber* Pursh (1016c) (Type).

This could be placed in *Macrophoma*, but there is no similar species described on *Penstemon*, in either genus.

**Phoma selenophomoides** sp. nov. (FIG. 19)

Pycnidia  $100\text{--}150\ \mu$  diametro, dense dispersa, depresso globosa, sub cuticula formata, deinde erumpentia, superficialia, et paulum collapsa. Conidia fusiformia, inaequilateralia vel paulum curvata, continua, hyalina, guttulata,  $12.5\text{--}14\ \mu$  longa,  $2\text{--}2.5\ \mu$  crassa.

Specimen typicum in caulibus vetustis *Erigerontis salsuginosi* Gray, prope Teton Pass, Jackson, Wyoming, 11 Jul., 1940, legit L. E. Wehmeyer, sub numero 1113c.

Pycnidia  $100\text{--}150\ \mu$  in diameter, shiny black, scattered locally, formed beneath the cuticle and soon erumpent-superficial, flattened-spheric, becoming somewhat collapsed, with a minute papillate ostiole. Conidia fusoid, inequilateral or somewhat curved, one-celled, hyaline, with small guttulae,  $12.5\text{--}14 \times 2\text{--}2.5\ \mu$ .

S. of Teton Pass: July 11, on *Erigeron salsuginosus* Gray (1113c) (Type).

This species is barely covered by the cuticle and soon becomes superficial and appearing as an *Aposphaeria*. The spores approach the shape of those found in *Selenophoma*.

**Macrophoma Mimuli** sp. nov. (FIG. 18)

Pycnidia dispersa, immersa, depressiuscule globosa,  $200\text{--}250\ \mu$  diametro; pariete  $40\text{--}50\ \mu$  crasso, ex parenchymate crasso, atro. Conidia continua, hyalina, cylindrici-fusiformia, recta vel paulum curvata,  $18\text{--}26\ \mu$  longa,  $5\text{--}6.5\ \mu$  crassa.

Specimen typicum in caulibus vetustis *Mimuli Lewisii* Pursh, secus viam "Skyline Trail," Teton National Park, Wyoming, 24 Jul., 1940, legit L. E. Wehmeyer, sub numero 1171d.

Pycnidia scattered, immersed, somewhat depressed-spheric,  $200\text{--}250\ \mu$  in diameter, walls thick ( $40\text{--}50\ \mu$ ), of coarse black pseudoparenchyma. Conidia one-celled, hyaline, cylindric to fusoid-cylindric, straight or slightly curved or bent,  $18\text{--}26 \times 5\text{--}6.5\ \mu$ .

Skyline Trail: July 24, on *Mimulus Lewisii* Pursh (1171a) (Type).

This is associated with *Apiosporella Mimuli* and may be its conidial stage.

**Phyllosticta Pachystimae** sp. nov.

Efficiens argentionem foliorum de causa separationis epidermatis a chlorenchymate. Pycnidia epiphylla, dense dispersa, in tota superficie folii, ut puncta minuta, irregularia, dispersa,  $150-170 \times 80-100 \mu$ , sub epidermate ruguloso; pariete tenuiusculo. Conidia ellipsoidalia vel fusiformiter ellipsoidalia, continua, hyalina,  $9-14 \mu$  longa,  $4-5 \mu$  crassa; pariete incrassato, in conidiophoris brevibus, apice angustatis.

Specimen typicum in foliis *Pachystimae Myrsinitis*, prope Granite Creek, Hoback Canyon, Jackson, Wyoming, 1 Aug., 1940, legit L. F. Wehmeyer, sub numero 1198.

Causing a graying or silvering of the leaves as a result of the separation of the epidermis from the internal tissues. Pycnidia epiphyllous, thickly scattered over the entire leaf surface as minute dots, flattened,  $150-170 \times 80-100 \mu$ , imbedded beneath the often wrinkled epidermis, irregular in shape, walls rather thin. Conidiophores short, taper-pointed, bearing the ovoid to fusoid-ellipsoid, one-celled, hyaline conidia, which are very thick-walled and measure  $9-14 \times 4-5 \mu$ .

Hoback Canyon: Granite Creek Canyon, Aug. 1, on *Pachystima Myrsinites* Raf. (1198) (Type).

**PHYLLOSTICTA ARNICAE** (Fck.) Sacc.

Forming large, circular, brown, dead spots, with a yellow margin. The conidia in this collection are cylindric, bacillar, hyaline,  $3-3.5 \times 0.5-0.8 \mu$ .

Hoback Canyon: Red Creek, June 30, on *Arnica* sp. (1186).

The conidia of *P. Arnicae* are given as  $6 \times 1 \mu$ , but Seaver (16), in his account of the Phyllostictales, gives the spores of a Colorado specimen as  $3-4 \times 1 \mu$ , and Solheim (17, 2, p. 96) gives the spores of a Wyoming specimen as  $3-5-7 \times 1 \mu$ . This collection seems to fit these American reports.

**RHABDOSPORA PLEOSPOROIDES** Sacc. var. *Drabae* var. nov.

Pycnidia dispersa, sub epidermate,  $200-400 \mu$  diametro, depressa, paulum collapsa vel cupuliformia; ostiolo brevi, cylindrico; pariete membranoso, parenchymatoso. Conidia longe fusiformia, acicularia, plerumque utrinque

athemata and interdum rotundata, longitudo in tres grupos inter se differentes separata, aut 8.5-14 aut 23-33 aut 40-50  $\mu$  longa, 0.8-1  $\mu$  crassa.

Specimen typicum in caulibus vetustis *Draba luteola* Greene, prope Red Creek, Hoback Canyon, Jackson, Wyoming, 29 Jul., 1940, legit L. E. Wehmeyer, sub numero 1185c.

Pycnidia scattered, subepidermal, 200-400  $\mu$  in diameter, flattened, somewhat collapsed or saucer-shaped, with a short cylindric, central ostiole, wall membranous, parenchymatous. Conidia long fusiform, needle-like, usually tapered at both ends, but sometimes rounded, one-celled, hyaline, occurring in three different length groups, 8.5-14, 23-33, or 40-50  $\times$  0.8-1  $\mu$ .

Hoback Canyon: Red Creek, July 29, on *Draba luteola* Greene (1185c) (Type).

When first examined this collection was assumed to have three species of *Septoria* upon it, because the spores in separate pycnidia seemed to be of different lengths. However, spores of several lengths were later often found in one and the same pycnidium. Spores of the two shorter lengths are the more common. All spores are of the same diameter and general shape. Whether these spores are formed in different lengths or are the result of fragmentation, could not definitely be determined, but the former seems to be the more probable case. There are often a few brownish rhizoidal hyphae growing out from the lower side of the pycnidium.

In general, this collection fits very well the description of *Rhabdospora Cirsii* Karst. Grove (8, 1, p. 437) gives *Septoria* (*Rhabdospora*) *pleosporoides* var. *Cirsii* Karst. as a synonym of this species and says that it is reported as the conidial stage of *Leptosphaeria dolioloides* var. *Cirsii* or *Ophiobolus Cirsii*. *Leptosphaeria eustoma* is found on the above stems of *Draba*. Several varieties of *R. pleosporoides* with spores varying from 20 to 52  $\mu$  in length have been described on different hosts. My collection no doubt belongs to this same species complex. It differs in the presence of three different length-groups among the spores.

SELENOPHOMA DONACIS var. STOMATICOLA (Bauml.) Sprague & A. G. Johnson (FIG. 20)

On surface as thickly scattered, seriatly arranged, circular to elliptic, black dots, which are the immersed pycnidia, 80-150  $\mu$  in

diameter, which open by a central pore-like ostiole, have a pseudo-parenchymatic wall and cause a slight grayish discoloration of the surface. Conidia lunate-fusoid, somewhat curved, ends acute, one-celled, hyaline,  $14-20 \times 1.5-2 \mu$ .

Cream Puff Mt.: July 5, on culms of an unidentified grass (1088a).

This material was sent to Dr. R. Sprague, who kindly identified it as the above variety (MYCOLOGIA 37: 639), characterized by the somewhat shorter spores.

**Selenophoma maculicola** sp. nov. (FIG. 21)

Pycnidia globosa vel depressa,  $100-200 \mu$  diametro, singula vel confluentia, stromatica, in maculis atris, minutis, ex hyphis fuscis, reptantibus, torulosus formatis. Conidia lunati-fusiformia, curvata, ad apicem acuta, unicellula, hyalina vel pallide lutea,  $23-26 \mu$  longa,  $4.5-5 \mu$  crassa.

Specimen typicum in caulibus vetustis *Pseudocymopteri anisati* (Gray) C. & R., prope Hoback Canyon, Jackson, Wyoming, 16 Jul., 1940, legit L. E. Wehmeyer, sub numero 1221a

Forming small blackened spots, consisting of radiating or mat-like masses of toruloid, dark brown hyphae, upon which the pycnidia arise as thickened, globose or flattened, often confluent masses with one or several cavities  $50-100 \mu$  in diameter. Pycnidia  $100-200 \mu$  in diameter. Conidia lunate-fusoid, somewhat curved, acute at the ends, one-celled, hyaline or faintly yellowish,  $23-26 \times 4.5-5 \mu$ .

Hoback Canyon: July 16, on *Pseudocymopterus anisatus* (Gray) C. & R. (1221a) (Type).

Dr. R. Sprague (in litt.), who kindly examined this material also, states that he has not seen this *Selenophoma* during his extensive studies of the genus. He rightly points out that the method of formation and character of the pycnidia are somewhat atypical for this genus.

**SEPTORIA PUNCTOIDEA** Karst.

Elk Refuge: Jackson, Wyo., July 1, on *Juncus filiformis* L. (1072d).

This species is associated with *Mycosphaerella perexigua* (see discussion (22) under that species).

## SEPTORIA SYMPHORICARPI E. &amp; E.

Spots irregular, 2–10 mm. in diameter, bounded by the veins, with a central tan, necrotic area, bearing the immersed, thin-walled pycnidia, which are 100–150  $\mu$  in diameter. Conidia long cylindric, occasionally somewhat fusoid toward the ends, often apparently uni- to tri-septate, 41–70  $\times$  2–2.5  $\mu$ .

Camp Davis: July 7, on *Symphoricarpos pauciflorus* (Robb.) Britt. (1093).

This fits the description of Ellis' species except for the larger spots and longer spores. Solheim (17, 3, p. 39) in describing a new species (*S. signalensis*) on *Symphoricarpos orophilus*, differing in the broader (3–4  $\mu$ ) spores, states that he finds the spores of *S. Symphoricarpi* to be 30–64  $\times$  2–2.5  $\mu$ , which would fit this collection.

**Sirexcupula wyomingensis** sp. nov. (FIGS. 23–24)

Pycnidia sub epidermate formantia, mox erumpentia et superficialia, 250–600  $\mu$  diametro, primum subglobosa vel modice depressa, deinde pezizoida vel irregulariter collapsa, cum uno papillo vel crista ventrali; pariete tenui, atriparenchymatico, sursum cellulis modice radiatis dispositis; ostiolo fissiformi, rimoso, aetate radiato. Conidiophori numerosi, filiformes, paralleles, hyalini, 60–100  $\mu$  longi, regulariter septati, in fragmenta cylindrica, bacilliformia, ut conidia unicellula, 7–9  $\mu$  longa, 2  $\mu$  crassa, separantes.

Specimen typicum in caulibus vetustis *Lupini candicantis* Rydb., prope Teton Pass, Jackson, Wyoming, 11 Jul., 1940, legit L. E. Wehmeyer, sub numero 1101c.

Pycnidia arising beneath the epidermis, but soon erumpent and then entirely superficial, 250–600  $\mu$  in diameter, subglobose or somewhat depressed at first, wall thin, composed of a thin outer layer (10–15  $\mu$ ) of dark walled pseudoparenchyma and a thicker inner layer (20–30  $\mu$ ) of thin-walled hyaline parenchyma, soon collapsing in a pezizoid or irregular fashion, leaving a central ostiole-like papilla or ridge. Surface wall slightly radiate in cell arrangement, ostiolar opening slit-like with a radiate splitting of the wall. Conidiophores consisting of numerous, parallel, filiform, hyaline hyphae, 60–100  $\mu$  long, from the inner cell walls, and becoming regularly septate into cylindric, bacilliform segments, which fall apart as the one-celled, hyaline conidia which are 7–9  $\times$  2  $\mu$ .

Togwotee Pass: On *Lupinus candicans* Rydb., July 8 (1101c) (Type).

S. of Teton Pass: July 11, on *Hedysarum uintahense* A. Nels. (1126a) and *Aquilegia coerulea* James (1114e).

The pycnidia of this species were, in some cases, found associated with those of *Heteropatella umbilicata* and have a structure very similar to those of the *Heteropatella*, but have entirely different spores. The radiate character of the upper wall is not so

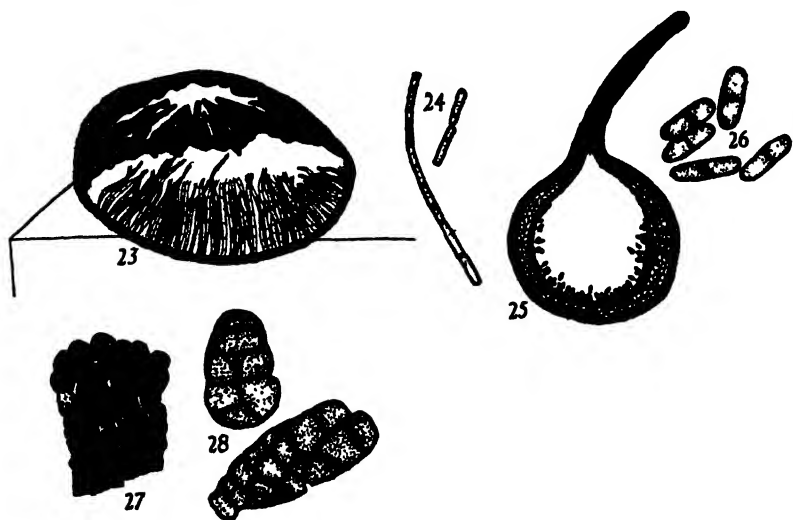


FIG. 23. Pycnidium of *Sirexscipula wyomingensis* sp. nov. to show radiate cell arrangement and ostiolar split of the upper wall and filiform, fragmenting conidiophores.

FIG. 24. Conidiophore of *Sirexscipula wyomingensis* sp. nov., to illustrate their fragmentation into conidia.

FIG. 25. Vertical section of pycnidium of *Pellionella tetonensis* sp. nov.

FIG. 26. Conidia of *Pellionella tetonensis* sp. nov.

FIG. 27. Portion of surface of stroma of *Steganosporium tuberculiforme* (E. & E.) comb. nov. showing manner of conidial formation.

FIG. 28. Conidia of *Steganosporium tuberculiforme* (E. & E.) comb. nov.

apparent, but the elongate ostiolar opening and the radiate splitting of the wall about it are characteristic of the Discellaceae. Even though the pycnidium does collapse in a pezizoid or wrinkled manner, it is definitely flattened-globose at first and might be placed in the Sphaeroidaceae on this basis. Of the genera with similar formation of the spores by septation of a filament, *Sirococcus* is given by Höhnelt (9, 16, p. 119) as belonging in the



Leptostromataceae and *Sirophoma* is described as being immersed in bark, with a flattened ostiole. *Desmopatella* Höhn. (10, p. 76), which is considered a conidial stage of *Heteropezisa*, has a flatter pycnidium and branched conidiophores. *Peckia*, as interpreted by Höhnelt (9, 16, p. 127) in *P. montana*, is without an ostiole and very similar. *Sirexipula*, which according to Bubak (1, p. 295) differs only in the one-celled spores from *Siropatella* (which, in turn, is described with similar elongate to radiately split ostioles), seems to fit even better.

The collection on *Aquilegia* exuded its immature conidiophores in their entirety, in which condition this species is easily mistaken for a *Septoria*. As in the case of *Heteropatella umbilicata*, these collections were all taken from elevations of 9000 feet or more.

***Steganosporium tuberculiforme* (E. & E.) comb. nov. (FIGS. 27-28)**

On surface as scattered, circular to elliptic, olive-black, granular, plane to concave discs, 250-500  $\mu$  in diameter, erumpent through the periderm and surrounded by a shallow collar of this tissue. Stromata consisting of a basal mass of coarse, thick-walled, black pseudoparenchyma, arranged more or less in parallel rows, and cutting off from the apical hyphae, all over the surface, conidia consisting of irregular, muriform, brown masses of cells, 17-32  $\times$  9-10.5  $\mu$ , or sometimes larger. These masses of cells appear to arise by the division of component groups of cells in the apical portion of the conidiophore hyphae. The individual cells are 4-5  $\mu$  in diameter.

S. of Teton Pass: July 11, on *Sambucus microbotrys* Rydb. (1133).

It is difficult to say in what genus this fungus should be placed. It would run to *Endobotryella* in the Melanconiaceae, but that genus and *Endobotryon*, according to Höhnelt (9, 9, p. 1534), are like *Thyrsidium*, with hyaline basal conidiophores. *Thyrostroma*, *Bonordoniella* and *Clathrococcum*, in the Tuberculariaceae, are also possibilities as is *Steganosporium*, in the Melanconiaceae.

*Sporodesmium*, under which generic name this species and *S. subcupulatum* were described by Ellis (4, p. 384), is in the Hyphomycetes, but Ellis describes both these species as "tuberculate" and

with muriform spores, subglobose to clavate-oblong in *S. subcupulatum* and sub-cuboid to subglobose in *S. tuberculiforme*. My material covers the spore range of both of these species, which are probably synonymous. It is difficult to interpret the irregular spores, but they are muriform at maturity, and since the fungus does not fit in *Endobotryella*, it is placed in *Steganosporium*. Since the second species described, *Sporodesmium tuberculiforme*, seems to fit my collection better, its specific name is used.

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### EXPLANATION OF FIGURES

(All spores are drawn to a scale of approximately 1 mm. equals 1  $\mu$ )

- FIG. 1. Conidia of *Apiocarpella Hedysari* sp. nov.
- FIG. 2. Conidia of *Apiocarpella macrospora* (Speg.) Syd.
- FIG. 3. Conidia of *Diplodina attenuata* sp. nov.
- FIG. 4. Vertical section of pycnidium of *Hendersonia pinicola* sp. nov. on pine needle.
- FIG. 5. Conidia of *Hendersonia pinicola* sp. nov.
- FIG. 6. Conidia of *Leptostroma Lupini* sp. nov.
- FIG. 7. Conidia of *Phoma bacilliformis* sp. nov.
- FIG. 8. Conidia of *Phoma pulchelicola* sp. nov.
- FIG. 9. Conidia of *Phoma jejuna* sp. nov.
- FIG. 10. Conidia of *Phoma minuta* sp. nov.
- FIG. 11. Conidia of *Phoma herbicola* sp. nov.
- FIG. 12. Conidia of *Phoma herbarum* West.
- FIG. 13. Conidia of *Phoma fusispora* sp. nov.
- FIG. 14. Conidia of *Phoma Pedicularis* sp. nov.
- FIG. 15. Conidia of *Phaeoseptoria Scirpi* sp. nov.
- FIG. 16. Conidia of *Phoma linearispora* sp. nov.
- FIG. 17. Conidia of *Phoma wyomingensis* sp. nov.
- FIG. 18. Conidia of *Macrophoma Mimuli* sp. nov.
- FIG. 19. Conidia of *Phoma selenophomoides* sp. nov.
- FIG. 20. Conidia of *Selenophoma Donacis* var. *stomaticola* (Baüml.) Sprague and Johnson.
- FIG. 21. Conidia of *Selenophoma maculicola* sp. nov.
- FIG. 22. Vertical section through pycnidial cavities of *Selenophoma maculicola* sp. nov.

# A PREVIOUSLY UNDESCRIBED FUNGUS CAUSING A LEAF SPOT OF BAMBOO

LELAND SHANOR<sup>1</sup>

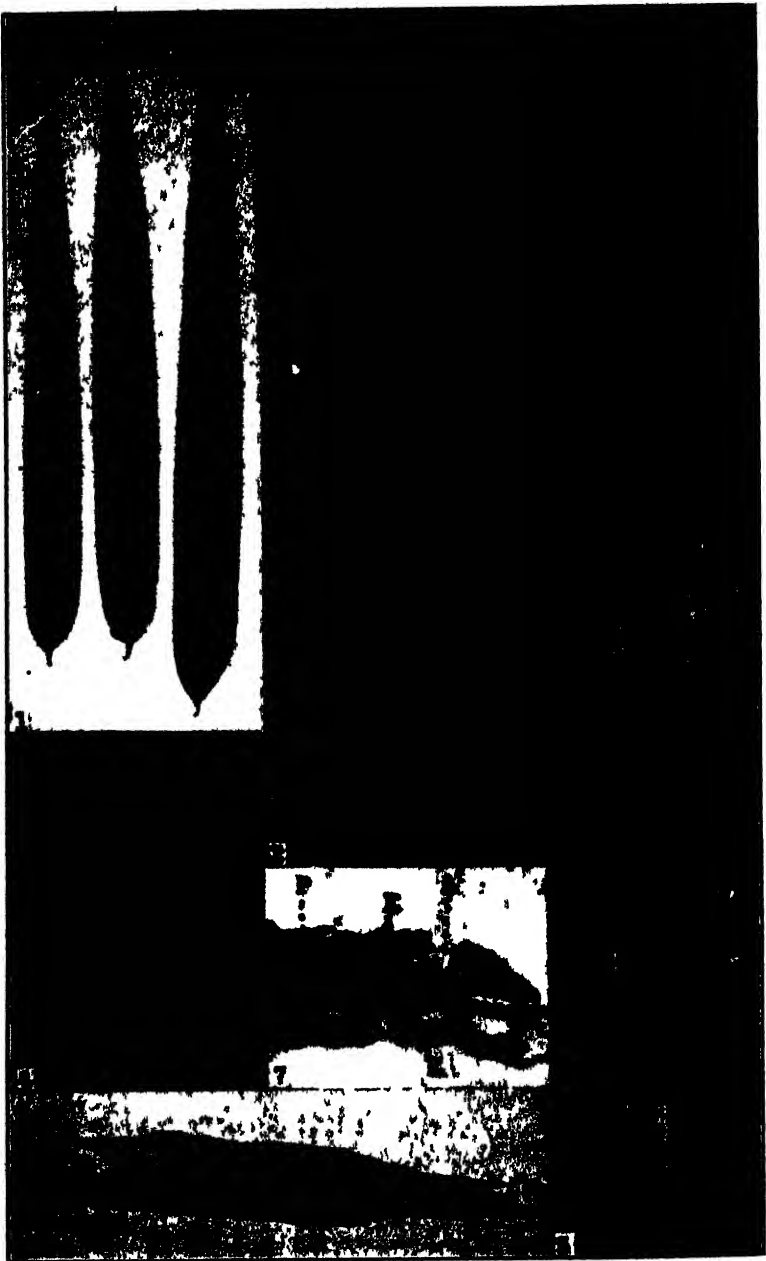
(WITH 8 FIGURES)

Although a considerable number of fungi have been reported as parasites of the leaves of bamboo, one occurring on specimens received by Mr. J. A. Stevenson of the Division of Mycology and Plant Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, from El Salvador, which causes a leaf spot of *Arthrostylidium racemiflorum* Steud., appears to be undescribed. This sample of infected leaves was sent by the Bureau of Entomology and Plant Quarantine with a request for a determination of the fungus causing the leaf spot. Additional leaves infected with the same fungus were found later when specimens of the same host which were on deposit in the United States National Herbarium, Washington, D. C., were examined.

Through the courtesy of Dr. H. L. Mason, Curator of the Herbarium, University of California, the entire El Salvador collection, Tucker no. 750, from which the original samples were taken was placed at my disposal for study. On the first leaves examined only a pycnidial fungus was found associated with the leaf spot disease but, when additional material was made available, ascomata were observed developing along with them. This material had been steam sterilized before it was received so that no opportunity to establish the relationship of the two phases by a comparison of cultures derived from conidia and from ascospores was afforded, as would be desirable, provided, of course, that this fungus could be grown on artificial media.

<sup>1</sup> Formerly Pathologist, Emergency Plant Disease Prevention Project, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture, Beltsville, Maryland.

The author wishes to express his sincere appreciation to Mr. J. A. Stevenson for placing the original samples at his disposal; to Dr. W. W. Diehl for helpful suggestions; to Miss Edith K. Cash for the preparation of the Latin diagnoses; and to Mrs. Agnes Chase for the determination of the host.



FIGS 1-7 Leaf spot of Bamboo.

## THE CHARACTERISTICS OF INFECTED AREAS

The spots caused by this organism are oval, linear, or fusiform in shape and quite small, seldom reaching a length greater than 5 mm. or a width greater than 2 mm. The tissue of the invaded areas becomes necrotic and, evidently soon after infection has occurred, diseased tissue turns a yellowish brown color. When the black stroma of the fungus has developed in them, the parasitized areas stand out quite strikingly in the green leaf tissue (FIGS. 1, 2, 3). Spots lack a definite margin but laterally are usually somewhat limited by the veins of the leaf and there is no evidence of a border of a different color surrounding them. The individual spots caused by a single infection are usually widely scattered on the leaflets but are sometimes sufficiently close together for their necrotic areas to coalesce (FIG. 2). The pycnidial stage of the fungus apparently precedes the ascocarpic stage and commonly is the only phase encountered on infected leaflets. In the material which I have examined, ascocarpic fructifications have never been seen to develop independently.

## THE PYCNIDIAL PHASE

Pycnidial stromata (FIGS. 2, 3, 6) develop within the leaf tissue, usually nearer one or the other of the epidermal layers, in all probability nearer that one through which infection occurred. The outer wall of each stroma is thicker than the inner one and as it

## EXPLANATION OF FIGURES 1-7

FIG. 1. Leaves of *Arthrostylidium racemiflorum* Steud. showing numerous infected areas caused by the leaf-spot fungus. Pycnidial and ascocarpic phases are both present on the central leaf; only pycnidial phase on the other two. Approx.  $\times 1$ .

FIGS. 2 and 3. Higher magnification of spots with pycnidial stromata. Approx.  $\times 10$ .

FIGS. 4 and 5. Higher magnification of spots with both pycnidial stromata and ascocarps. Figure 4 of dry material; figure 5 after soaking 1 hour in distilled water. Approx.  $\times 10$ .

FIG. 6. Median longitudinal section through a pycnidial stroma showing locules filled with conidia. Approx.  $\times 72$ .

FIG. 7. Cross section through pycnidial stroma (P) and ascocarp (A) showing attachment of the ascocarp through ruptured epidermis of leaf (E). Approx.  $\times 100$ . (Figures 1-5 by Robt.<sup>9</sup> Taylor; figures 6 and 7 by the author.)

develops the epidermal cells become somewhat confluent with it. Stromata are elongate and contain one to four locules separated by parenchymatous walls (FIG. 6). The outer walls of the stromata are made up of compact angular or somewhat rounded cells with thickened walls which are carbonaceous and brittle. The inner wall is not so thick and the cells are not so carbonaceous as those of the outer wall.

Conidia develop on conidiophores which line the cavities of the stroma. Conidiophores (FIG. 8) are cylindrical and each appears

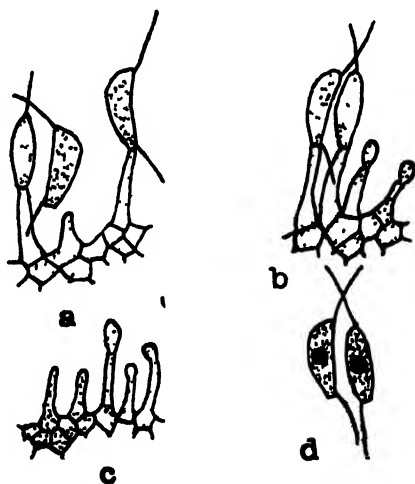


FIG 8 Camera lucida drawings of mature and immature conidia, conidiophores and associated cells (a-c, from unstained material; d, from material stained with phloxine)  $\times 650$

to give rise to a single conidium. Conidia are produced in great abundance and are deposited within the cavity of the locules (FIG. 6). A gelatinous matrix appears to be formed within the cavities along with the spores, for conidia have a strong tendency to remain together when spores emerge from pycnidia naturally or when stromata are crushed in water. When mature stromata are moistened, the expansion of the locule contents causes an irregular longitudinal rupturing of the wall, thus making it possible for the spores to escape. Conidia are hyaline, single-celled, and have two straight or slightly curved setae which are attached slightly to one side, one near each end of the spore (FIG. 8). They are slightly

clavate to navicular in shape and measure up to  $16.5 \times 5.5 \mu$ , and setae measure usually about  $12 \mu$  in length.

This pycnidial stage possesses generic characteristics similar to those ascribed to *Ciliochorella* Sydow and Mitter (1935) and since the pycnidial stage has been encountered frequently without an associated ascocarpic stage, it is here included in this genus, being designated as a new species. Its key characters also lead to the genus *Diachorella* Hoehnel (1923) which was included in the phyllachoroid *Pachystromaceae* in his *System der Fungi Imperfecti* Fuckel. *Diachorella*, however, was not provided with a type species, so according to the International Rules of Botanical Nomenclature cannot be recognized as valid. Clements and Shear (1931) noted that *Diachorella* Hoehnel was not provided with a type species and Sydow and Mitter (1935) also pointed this out. Ainsworth and Bisby (1941) recorded *Diachorella* as a nomen nudum.

#### ***Ciliochorella bambusarum* sp. nov.**

Stromata in maculis insidentia, nigra, plerumque singula sed interdum aggregata, ovalia vel linearia, subconvexa, carbonacea, innata, usque 2.5 mm. longa et 0.5 mm. lata, plurimum  $1 \times 0.25$  mm., in centro usque 0.25 mm. crassa, pariete exteriori carbonaceo et prosenchymatico, e cellulis angularibus vel subrotundis composito, pariete interiori tenuiori et minus carbonaceo; loculi 1-4, conidiophoris vestiti, in maturitate rima irregulari longitudinali dehiscentes; conidiophora cylindrica usque anguste clavata,  $10-26 \mu$  longa,  $2-2.5 \mu$  lata; conidia abundantia, anguste clavata vel navicularia, hyalina, unicellularia, truncata,  $14-16.5 \mu$  longa,  $4.75-5.2 \mu$  lata, utrinque sub apice setula prominenti recta vel subcurvata  $9-15 \mu$  longa praedita.

On *Arthrostyloidium racemiflorum* Steud., John Tucker no. 750, collected January 8, 1942, growing on steep west facing canyon slope in coffee plantation, south side of Mt. Cocoquatique, El Salvador, at an elevation of about 4500 ft. The type (Tucker no. 715A) has been placed in the Mycological Collections of the Bureau of Plant Industry. Isotypes are being deposited with the Herbarium of the University of California, Berkeley, with the Farlow Herbarium of Harvard University and with the Herbarium of the University of Illinois.

This fungus has also been observed on scattered leaves of the following collections of *A. racemiflorum* Steud. in the United States National Herbarium:



- (1) Mexico, Jan. 5–Feb. 6, 1892. Edward Palmer 1914 (U. S. Nat. Herb. no. 1, 021, 482).
- (2) Telaran, Province of Guanacaste, Costa Rica, Paul C. Standley and Juvenal Valerio 45, 665 (U. S. Nat. Herb. no. 1,307, 183).
- (3) Ahuachapan, Department of Ahuachapan, El Salvador, Jan. 8–27, 1922. Paul C. Standley 19, 995 (U. S. Nat. Herb. no. 1, 135, 822).
- (4) Panama Canal Zone, July 1923. H. Johansen 17 (U. S. Nat. Herb. no. 1, 167, 472).

#### THE ASCOCARPIC PHASE

Ascomata of this leaf-spot fungus appear to develop only from the stroma of the imperfect stage, for, when the perfect stage is present, it has always been found associated with pycnidial stromata.

Ascomata develop to the side of pycnidia, usually near either one or both ends of the stroma, forming a superficial laterally-attached fructification (FIGS. 4, 5, 7). These fruiting bodies are usually less than 1 mm. in length, are fusiform to somewhat allantoid in shape, and are jet black in color. The roof of the ascocarp is arched, made up of heavily carbonized cells, and opens by an irregular median longitudinal slit. The basal plate is made up of pseudoparenchymatous cells which are carbonized but not as heavily as the roof tissue. The radiate development of ascomata is clearly evident in young ascocarps and along the margins of more mature fruiting bodies.

Asci arise from a flattened basal layer, are narrowly clavate with short stalks and measure 55–69  $\mu$  long by 10–12  $\mu$  wide. Ascospores are eight in number, ovoid, and pointed at one end, hyaline, one-celled, measuring 13.8–14.5  $\mu$  in length by 4.5  $\mu$  at widest point.

Features of the fungus clearly indicate that it belongs in the Hemisphaerales in the system of classification as understood by Theissen and Sydow (1917). It might be considered as a somewhat aberrant member of the family Polystomellaceae since the lateral attachment could be regarded as equivalent to a central column. Gäumann and Dodge (1928) in discussing the char-

acteristics of this family call specific attention to the central column or columns by which the ascomata of fungi belonging to this group are attached to the host tissue. The lateral attachment of the ascomata to a pycnidial stroma, which in this case might be compared to the hypostroma of other genera, is a fundamental and outstanding feature which clearly characterizes a distinct genus. A genus having this distinguishing feature apparently has not been described, so it becomes necessary to establish a new genus for the bamboo leaf-spot fungus.

**Lateropeltis** gen. nov.

Ascomata parva, nigra, lateraliter affixa, marginibus radiata, e fusiformibus allantoidea, rima irregulari mediana longitudinali aperta; asci anguste clavati, breve pedicellati; ascosporae hyalinae, unicellulares; paraphyses praesentes.

**Lateropeltis bamousarum** sp. nov.

Ascomata superficialia, ad stromata pycnidica lateraliter affixa, nigra, usque 1 mm. longa e fusiformibus allantoidea; tecto arcuato e cellulis dense carbonaceis composito, rima irregulari mediana longitudinali aperto, strato basali pseudoparenchymatico; asci e strato basali applanato orti, anguste clavati, breve pedicellati,  $55-69 \times 10-12 \mu$ ; ascosporae 8, ovoideae, apice uno acutae, hyalinae, unicellulares,  $13.8-14.5 \times 4.5 \mu$ ; paraphyses simplices (?).

On *Arthrostyloidium racemiflorum* Steud., associated with pycnidial phase, John Tucker no. 750, collected January 8, 1942, growing on steep west facing canyon slope in coffee plantation, south side of Mt. Cocoquatique, El Salvador, at an elevation of about 4500 ft. The type (Tucker no. 751B) has been placed in the Mycological Collections of the Bureau of Plant Industry. Isotypes are being deposited with the Herbarium of the University of California, Berkeley, with the Farlow Herbarium of Harvard University, and with the Herbarium of the University of Illinois.

Additional ascomata have been found on scattered leaves of a collection of *A. racemiflorum* Steud., Panama Canal Zone, July 1923. H. Johansen 17 (U. S. Nat. Herb. no. 1, 167, 472).

SUMMARY

A fungus causing a leaf spot of a bamboo, *Arthrostyloidium racemiflorum* Steud., is described. The pycnidial stage occurred

abundantly on the material studied and has been designated as *Ciliochorella bambusarum* sp. nov. The ascocarpic stage is a hemisphaeriaceous fungus, placed in a new genus, *Lateropeltis*, a genus distinguished by having ascomata laterally attached to the stroma of the pycnidial stage. The ascogenous stage of this fungus is not known to occur except in conjunction with the pycnidial phase.

URBANA, ILLINOIS

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## STUDIES ON SOME CALIFORNIA FUNGI. III

LEE BONAR

Studies on material from my own collections as well as those sent in by others have afforded numerous records of the extension of the known range of distribution, new host records and so forth. Some of these along with the description of certain new species are considered worthy of publication.

PHYSODERMA HYDROCOTYLIDIS Viegas and Teixeira, *Bragantia* 3: 8, 226-228. 1943.

A small collection of this species on *Hydrocotyle ranunculoides* L. was made at Berkeley, California, November 1930. Preliminary examination suggested that this might be *Entyloma hydrocotylis* Speg. A portion of the material was sent to Dr. G. P. Clinton for identification. He replied that it was not a smut but a chytrid. Further studies were not made at that time, and repeated search for more material failed until September 1943, when it appeared in abundance in the same pools at Berkeley. A more critical study was undertaken and the material proved to be similar to a collection in the University of California Herbarium from Golden Gate Park, San Francisco, June 1930, W. W. Diehl. Correspondence with Dr. Diehl revealed that he had compiled records of various collections for the United States and attention was also called to the description cited above on *Hydrocotyle reniformis* Spreng. from Brazil. Our material proves to be the same species and checks with specimens from Brazil, supplied by Dr. Viegas. Dr. Diehl has kindly permitted me to include the records of the distribution of the species compiled by himself and Dr. E. F. Guba.

On *Hydrocotyle ranunculoides* L. Black Pond, Fairfax Co., Va., June-October 1923 (5 coll.) Diehl, November 21, 1923, Guba and Diehl; Golden Gate Park, San Francisco, California, June 8, 26, 1930, Diehl; Berkeley, California, October 1930, H. E. Parks, No-

vember 21, 1930 and September 21, 1943, Lee Bonar; Mobile, Alabama, May 22, 1889, Charles Mohr 464, *ex* U. S. Natl. Herb. 770075; York Furnace (Pa.), August 20, 1895, *ex* Herb. Jos. Crawford (in Herb. Phila. Acad.); St. Georges, Del., July 22, 1875, A. Commons (in Herb. Phila. Acad.).

Dr. E. F. Guba reported presence of the fungus on specimens in the phanerogamic herbarium of Cornell University as follows:

On *Hydrocotyle* sp., Cape May, N. J., Aug. 30, 1897, A. Gershoy.

On *H. ranunculoides*, Appalachicola, Fla., 1893, A. W. Chapman.

On *H. umbellata* L., Riverside, Calif., Dec. 17, 1918, M. F. Barrus.

The correct identity of *Entyloma hydrocotylis* Speg. remains in question. Dr. A. P. Viegas informs me (personal communication) that he has examined the type specimen and finds that it is not a species of *Entyloma*, but has been unable to settle the point as to its correct disposition.

*Physoderma hydrocotylidis* V. & T. is near to *Physoderma vagans* Schroet. but distinguished by the sporangia being smaller with colorless walls, whereas those of *P. vagans* develop a distinct brown color. The sporangia of *P. vagans* were described as "verrucis" but critical examination of material from Bamberg, Bavaria, reveals only smooth-walled sporangia.

COLEROA CHAETOMIUM (Kze.) Rabh. var. AMERICANA Petrak, Ann. Mycol. 20: 181. 1922.

On living leaves of *Rubus leucodermis* Dougl., Lemonade Springs, South Fork Mountain, Trinity Co., Calif., August 28, 1941, H. E. Parks and J. P. Tracy, No. 11514.

This variety was described from material collected in Pend Oreille Co., Washington, and its presence in northern California on the same host extends its known range. The rather severe infection on these native plants suggests that it may be a potential danger to the nearly related cultivated raspberries. The variety is distinguished by its glabrous perithecia from the European species *C. Chaetomium*, which is a common parasite on cultivated raspberries.

## GUIGNARDIA CAMELLIAE (Cke.) Butler

On living leaves of *Thea sinensis* L. (*Camellia sinensis* Kunze) in Strybing Arboretum, Golden Gate Park, San Francisco, California, June 9, 1944, Lee Bonar. The host plants were grown from seed and no other tea plants are known from the vicinity. The appearance of the fungus in this area under these conditions is surprising.

## HYALOPSORA CHEILANTHIS (Pk.) Arth.

On *Adiantum emarginatum* Hook., near mouth of South Fork of Trinity River, Trinity Co., Calif., March 1927, March 1941, J. P. Tracy, Nos. 7856 and 16842. These collections establish a new host for this rust and there were only scant infections on the leaves. Both were found in association with more abundant infections of the rust on its common host, *Gymnogramma triangularis* Kaulf.

## PUCCINIA OXALIDIS (Lév.) Diet. &amp; Ellis

This species has been reported in the United States from Louisiana, Texas and New Mexico. The uredial stage was collected at Berkeley, California, October 19, 1942, Lee Bonar, on *Oxalis rubra* St. Hil., which is an escape on the University of California campus. A second collection was made at Hamilton City, Glenn Co., California, May 8, 1944, E. B. Copeland, on *Oxalis Bowiciana* Lodd., which was in cultivation in a garden. Examinations of the Berkeley area through three following seasons have failed to show any recurrence of the infection or spread to near-by plants of native species of *Oxalis*.

## FISTULINA HEPATICA (Huds.) Fr.

This well known species is apparently rare in the Pacific Coast states, but available records show collections from Bald Mountain, near Korb, Humboldt Co., Calif., R. J. Kelley, October 25, 1918, on *Lithocarpus densiflora* (H. & A.) Rehd. (an immature specimen) and from Inverness, Marin Co., California, B. Schreiber, November 1936, Lee Bonar, November 1937, on *Castanopsis chrysophylla* D. C. Later observations have shown the sporophores appearing on the same tree in successive years at the Marin Co. site.

ARTICULARIELLA AURANTIACA (Ell. & Mart.) Höhn., Sitz. K. Akad. Wiss. Wien 118: 410-411. 1909.

*Ascomycetella aurantiaca* Ell. & Mart. Jour. Mycol. 1: 97. 1885.

*Leptophyma aurantiacum* (E. & M.) Sacc. Syll. Fung. 8: 845. 1889.

Ellis and Martin described both the ascus and conidial stages of this species from the leaves of *Quercus laurifolia* Michx., from Florida, giving no name to the conidial stage which was distinct from any established form genus in the Fungi Imperfecti. Von Höhnelt erected the form genus *Articulariella* to characterize the conidial form, making his studies from the original collection.

Collections of this species were made by J. M. Linsdale, Hastings Reservation, Monterey Co., California, Oct. 18 and Nov. 10, 1942, on the leaves of *Quercus lobata* Née. These collections show only the conidial stage. This extends the known distribution and host range of the species.

### ***Ascochyta salicis* sp. nov.**

Maculis dispersis, 2-10 mm. diam., angularis, a venis atris limitatis, badii, infra cinereis; pycnidiis hypophyllis, coarctatis, globosis, 80-145  $\mu$  diam., muris membranaceis, atris, ostiolo poroso; conidiis fusiformis, rectis aut aliquantulis curvatis, uniseptatis (raro biseptatis), vix constrictis ad septis, hyalinis, 28-40  $\times$  4-7  $\mu$ , saepe in cirrhis albidis; conidiophoris indistinctis.

Spots scattered, 2-10 mm. diameter, angular, limited by darkened veins, bay brown, cinereous below; pycnidia hypophyllous, crowded, subepidermal, erumpent, globoid, 80-145  $\mu$  diameter; wall membranaceous, carbonaceous; ostiole poroid; conidia fusiform, straight or slightly curved, uniseptate (very rarely biseptate), barely constricted at septum, hyaline, 28-40  $\times$  4-7  $\mu$ , frequently in white cirrhi; conidiophores very short and indistinct, up to 5  $\mu$  long.

On living leaves of *Salix laevigata* Behb., Hastings Reservation, Monterey Co., California, April to June 1941, 5 colls., J. M. Linsdale (type), June 12, 1941, Univ. Calif. Herb. No. 697789.

This species is assigned to the genus *Ascochyta* since the mature conidia in the extruded cirrhi are normally uniseptate even though a fraction of one per cent of them may develop a second septum.

**Cercospora ligusticicola** sp. nov.

Maculis elongatis ellipticis, usque 5 mm. longitudinis, saepe confluentibus, fulvidis; conidiophoris hypophyllis, raris amphigenis, delicatulis, albidulis, erumpentibus ex stromatis minutis, 1-15 in fascia,  $25-50 \times 3-4 \mu$ , subhyalinis vel fuscis; conidiis cylindratis, ad apices acuta, usque quadrisepatis, subhyalinis,  $40-65 \times 3-4 \mu$ .

Spots elongate elliptic, up to 5 mm. long, becoming confluent, fulvescent; conidiophores hypophyllous, rarely amphigenous, delicate, albescent, emerging from small stromata, 1-15 in a fascicle,  $25-50 \times 3-4 \mu$ , subhyaline to fuscous; conidia cylindric, acute at the tips, up to 4-septate, subhyaline,  $40-65 \times 3-4 \mu$ .

On living leaves of *Ligusticum Grayii* C. & R., Bear Creek, Plumas Co., Calif., July 30, 1942, Lee Bonar (type). Univ. Calif. Herb. No. 697787. Portion in Cornell University Herbarium.

I am indebted to Dr. Charles Chupp for aid in the study of this species.

**PLEUROTHYRIUM LONGISSIMUM** (Lib.) Bubak, Ber. d. Deuts. Bot. Ges. 34: 321-322. 1916.

On dead leaf stalks of *Athyrium filix-femina* (L.) Roth var. *californica* Butters, Butte Meadows, Butte Co., Calif., June 1943, E. B. Copeland.

This species was originally described as *Leptostroma longissimum* Lib., Plantae Cryptogamae Arduennae Fasc. III. 1834. Bubak later studied the original material and renamed it. I find no other records of collections. Our material agrees well with the description given by Bubak, except that the spores are found to be  $70-110 \times 1.5-2 \mu$ , and to have up to fifteen septa. Bubak noted that the original material was somewhat immature whereas the recent collection has abundant mature spores.

**RAMULARIA LOPANTHI** Ell. & Ev., Bull. Torr. Bot. Cl. 24: 472. 1897.

This species was described from a collection by J. J. Davis, No. 9511, from Yosemite, California, June 1895. It was listed as on the leaves of *Lopanthus scrophulariaefolius* Willd., which has been changed to *Agastache scrophulariaefolius* (Willd.) O. Kuntze. This species is not known to occur in the Pacific Coast states, so



that the host determination for the original collection was evidently incorrect.

Typical material of this fungus was collected along Bear Creek, Plumas Co., California, July 1942, Lee Bonar, on *Agastache urticifolia* (Benth.) O. Kuntze and the original collection was probably on this same common Sierran species.

**Ramularia Phaceliae** sp. nov.

Maculis irregularis, saepe confluentibus, partem magnam foliorum occupantibus, fulvescentis, infra cinereis; conidiophoris solitaris, raro caespitosis, numerosis, simplicibus, directis aut raro geniculatis, paucis septatis,  $20-40 \times 3-4 \mu$ ; conidiis solitariis vel catenulatis, cylindraco-ellipsoideis, hyalinis, 1-3-septatis, cicatricibus terminalibus manifestis,  $30-40 \times 5-7 \mu$ .

Spots irregular, becoming confluent and occupying most of the leaf, fulvescent, cinereous below; conidiophores single to rarely cespitose, abundant, simple, straight or rarely geniculate, sparingly septate,  $20-40 \times 3-4 \mu$ ; conidia solitary to catenulate, cylindric-ellipsoid, hyaline, 1-3-septate, terminal scars evident,  $30-40 \times 5-7 \mu$ .

On living leaves of *Phacelia proccra* Gray, Gold Lake, Plumas Co., Calif., July 31, 1942, Lee Bonar (type), Univ. Calif. Herb. No. 697788.

This species is near to *Ramularia Hydrophylli* Ell. & Ev., but is distinguished by being strictly hypophyllous, having conidiophores predominantly simple and straight, and by the longer non-clavate conidia.

RAMULARIA SIDALCEAE Ell. & Ev., Jour. Mycol. 4: 1. 1888.

Collected on living leaves of *Sidalcea asprella* Greene, along Bear Creek, Plumas Co., California, July 1942, Lee Bonar. This represents a new host and extension of the range recorded for the species.

**Septogloeum Cercocarpi** sp. nov.

Maculis dispersis, irregularis, saepe confluentibus, fulvis, infra cinereis-brunneis, margine definito; acervulis hypophyllis, subepidermalibus, erumpentibus.  $150-225 \mu$  diam., contextu basilari hyalino; conidiophoris  $7-10 \times 3 \mu$ ; massis sporidiorum cremeis, bullatis; conidiis clavati-cylindracois, curvatis ad spiralis, hyalinis, 1-3-septatis,  $27-38 \times 6-8.5 \mu$ .

Spots scattered, irregular, often confluent, fulvous, cinereous brown below, margin distinct; acervuli hypophyllous, subepidermal, erumpent, 150–225  $\mu$  diameter, basal layer hyaline; conidiophores 7–10  $\times$  3  $\mu$ ; spore masses cremeous, bullate; conidia clavate-cylindric, curved to spirally bent, hyaline, 1–3-septate, 27–38  $\times$  6–8.5  $\mu$ .

On living leaves of *Cercocarpus betuloides* Nutt., Hastings Reservation, Monterey Co., Calif., June 1, 1941 (type), Univ. Calif. Herb. No. 697790, July 3, 1941, J. M. Linsdale; Piru, Ventura Co., Calif., April 17, 1934, A. D. Gifford; Santa Catalina Island, Calif., July 4, 1909, F. M. Reed.

SEPTOGLOEUM MACULANS Hark., Bull. Calif. Acad. Sci. 1: 32. 1884.

This is a very local species as evidenced by the fact that recent collections on *Salix lasiolepis* Benth., July 1941 and June 1944, are from the exact locality of the original Harkness collection of 1882, yet this fungus has not been recorded from any other area. It is distinct from *Septogloeum salicinum* (Pk.) Sacc., in that the spots are larger and very dark brown, also in the spores which are frequently very strongly curved and have a distinctly greater width, up to 11 microns in diameter. The radiate fibrous character of the spots emphasized by Ellis, Jour. Mycol. 1: 117, and by Dearness, Mycologia 9: 361, is not a consistent character in the Harkness collection in the California Academy of Sciences Herbarium; nor in the recent collections. This is instead a wrinkling of the cuticle of the leaf around the margin of the spots as well as in other areas of the dried leaves and not apparent in the fresh material.

**Septoria Fremontiae** nom. nov.

*Septoria angularis* Hansen and Thomas, Madroño 8: 42. 1945.

On leaves of *Fremontia mexicana* (Davidson) McBride.

*Septoria angularis* Dearn., and Barth., Mycologia 8: 103, 1913, on *Solidago latifolia* L., has priority and necessitates the assignment of another name to the species on *Fremontia*, since it is quite distinct from that on *Solidago*.

## NOTES AND BRIEF ARTICLES

### AEROSOL OT IN THE PREPARATION OF MICROSCOPIC MOUNTS OF FUNGI

In making mounts for the microscopic examination of various fungi with aerial sporulation, difficulty is often encountered in wetting the conidia and conidiophores in water. It has been customary to use 70 per cent alcohol as a wetting agent in the preparation of the mount but the alcohol treatment is not always satisfactory because of its dehydrating effect upon the protoplasm and the rapid evaporation of the alcohol at the surface, causing violent currents which disrupt the arrangement of the conidial head. It was suggested to me by Dr. Gerrard Macleod of the Upjohn Company that the wetting agent, Aerosol OT, might be useful as a substitute for alcohol. In the past year I have used successfully a 1 per cent aqueous solution of Aerosol OT in the preparation of hundreds of temporary mounts of the *Aspergilli*, *Penicillia*, *Mucorales*, *Actinomycetes*, and a miscellaneous group of *Hyphomycetes*. The Aerosol solution serves not only as a wetting agent but also as a mounting medium which is readily miscible with the lacto-phenol mixture commonly used in the preservation of the temporary mount. Since I have seen no report in the literature of the use of Aerosol OT as a wetting agent for microscopic mounts of the fungi, the publication of this note seemed to me to be advisable.

Aerosol OT is manufactured by the American Cyanamid and Chemical Corporation. It is advisable to purchase Aerosol OT-100%, a waxy solid which will dissolve slowly in distilled water.—  
ALMA J. WHIFFEN.

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### ISOLATION OF *THIELAVIOPSIS BASICOLA* FROM SOIL BY MEANS OF CARROT DISKS

In attempting to isolate *Sclerotinia sclerotiorum* from soils and plant debris by means of living carrot slices, which are highly sus-

ceptible, very little *Sclerotinia* was isolated, but *Thielaviopsis basicola* (Berk. and Br.) Ferraris was isolated in abundance from a number of soils. This method of isolation appears superior to the methods previously published by Gilbert<sup>1</sup> and Levykh.<sup>2</sup>

Soils from field collections were spread over the surface of 5 mm. thick carrot root disks in petri dishes and enough water was added by atomizing to make the soil quite moist but with no free water present. After two to four days at room temperature the disks were washed to free them of soil and incubated in moist chambers. When soils containing *Thielaviopsis* were used as inoculum, grayish colonies appeared in about six<sup>1</sup>/<sub>2</sub> days after inoculation. At first masses of endoconidia were formed, and later the colonies turned almost black as macroconidia were formed in abundance. Transfers direct from the aerial mycelium to potato dextrose agar gave pure cultures of *Thielaviopsis* in most cases. There was no apparent discoloration or decay of the carrot disks until about ten days after inoculation, and microscopic examination of stained free hand sections indicated that the mycelium had penetrated between and within the cells without disorganizing them until invasion was well advanced. Cultures on carrot disks, like cultures on agar, yielded a strong odor of amyl acetate. When dilute spore suspensions from pure cultures of *Thielaviopsis* from agar cultures were used as inoculum and the carrot slices were therefore not washed after inoculation, *Thielaviopsis* colonies could be counted in three days.

Of seventeen soil collections from twelve locations in the San Francisco Bay and Santa Clara Valley regions, *Thielaviopsis* was isolated in twelve collections at seven locations. The two most abundant sources were an ornamental garden in Berkeley, and an apricot orchard near Hollister. In one test from the flower bed, all of seventeen test disks showed *Thielaviopsis* and most of them showed several colonies. A collection from a carrot field where carrots had been raised frequently in previous years yielded

<sup>1</sup> Gilbert, W. W. An improved method of isolation of *Thielavia basicola*. *Phytopath.* 16: 579. 1926.

<sup>2</sup> Levykh, P. M. (Translated title.) Methods of determining the degree of soil infestation with chlamydospores of *Thielaviopsis basicola* (Berk.) Ferraris. Abstract in *Rev. Appl. Myc.* 17: 710-711. 1938.

*Thielaviopsis* on only one of eight test disks. Of two hundred and forty disks in all tests, *Thielaviopsis* was isolated on sixty-six. In none of the locations was *Thielaviopsis* observed as a pathogen of the crops grown there.—C. E. YARWOOD.

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#### NOTE ON BAGNISIOPSIS

Recently the writer has received parts of type material of *Phyllachora mexicana* Sacc., *Bagnisiopsis orellana* Syd. and *B. puyana* Syd. from Dr. Th. Arwidsson of the Botanical Museum of Stockholm. At the time of writing the paper, "Bagnisiopsis species on the Melastomaceae" (*Mycologia* 35: 312-334. 1943) it was impossible to obtain these from Europe.

*Bagnisiopsis orellana* Syd. on *Miconia crocea* Naud. No. 1182, Sydow, Fungi exotici exsiccati and No. 177, Sydow Fungi Aequatoriensis, both have small, black orbicular stromata with no spines and with spores  $9-16 \times 7-12 \mu$ , and so this name becomes a synonym of *B. tijucensis* Theiss. & Syd.

The other two specimens, *Phyllachora mexicana* Sacc. on *Miconia* sp. collected by Bonansea, and No. 1183 *Bagnisiopsis puyana* Syd., Fungi exotici exsiccati, on *Miconia pujanae* Markgr., both have the macroscopic appearance of *B. tijucensis*, but are immature with no ascospores and so cannot be placed in a specific position.—JULIAN H. MILLER.

#### A NEW WESTERN POLYPORE

W. A. MURRILL

A fine new polypore was collected last fall in a coniferous forest in the state of Washington by Dr. A. S. Rhoads, who made complete notes on the fresh specimens.

#### *Scutigera skamanianus* sp. nov.

Pileo subplano,  $19 \times 16 \times 3$  cm., griseo, dein fuligineo, subfibrilloso, atromaculoso; tubulis decurrentibus, sulphureis, 1-2 per mm., angulatis, dein fibratis; sporis ellipsoideis, levibus, hyalinis,  $7.5-8 \times 6.5 \mu$ ; stipite solido, bulboso, atromaculoso,  $15 \times 5-5.5$  cm.

Pileus subcircular, plane or slightly depressed,  $19 \times 16$  cm., up to 3 cm. thick; surface grayish, becoming grayish-brown to fuliginous with age, slightly fibrillose, decorated with conspicuous darker spots; margin thin, concolorous, sharply inflexed; context fleshy-tough, pallid, homogeneous; tubes decurrent to the base of the stipe, short, pale-sulphur-yellow, deeper yellow on the stipe, mouths 1–2 per mm., angular, uneven or eroded on the rather thin edges; spores broadly ellipsoid, smooth, hyaline,  $7.5\text{--}8 \times 6.5 \mu$ ; stipe solid, rigid when dry, bulbous, tapering upward, reticulate, blotched with gray or dark-brown as though stained,  $15 \times 5\text{--}5.5$  cm.

Type collected by A. S. Rhoads, on the ground among conifers in the Wind River Experimental Forest, Skamania Co., Wash., about 1400 ft. elevation, Oct. 25, 1945 (*F* 19288). A small specimen was growing attached to the large one used as the basis for notes. For those using Saccardo the combination *Polyporus skamanius* is made.

## WANTED

MYCOLOGIA, volume 32, no. 3; volume 33, nos. 2 and 3. Through wartime losses these numbers have been exhausted or reduced to the danger point. The Managing Editor will be glad to pay for any of the above parts available.—FRED J. SEAVER, THE NEW YORK BOTANICAL GARDEN.



# MYCOLOGIA

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## NORTH AMERICAN SPECIES OF *DERMEA* <sup>1</sup>

J. WALTON GROVES <sup>2</sup>

(WITH 57 FIGURES)

### INTRODUCTION

In 1932, at the suggestion of Professor H. S. Jackson, the writer undertook the cultural study of life histories in the family Dermateaceae. The work was begun that year at the field laboratory of the Department of Botany, University of Toronto, at Bear Island, Lake Timagami, Ontario, and was continued there during succeeding summers, and at the University of Toronto until 1936. Since then it has been continued at the Division of Botany and Plant Pathology, Central Experimental Farm, Ottawa.

The aim at first was not primarily taxonomic but was to establish definitely by cultural technique the conidial relations of as many species of this group as could be collected and to make a comparative study of the conidial stages. However, as the work progressed, the importance of its bearing on the taxonomy of the group became increasingly apparent, and as an outgrowth of this work an attempt is now being made to bring together for the first time all the species of *Dermea* known in North America.

This study is based, for the most part, upon the writer's own collections and cultural studies, the specimens in the Mycological Herbarium of the Department of Botany, University of Toronto;

<sup>1</sup> Contribution No. 825 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

<sup>2</sup> Associate Plant Pathologist, Central Laboratory, Ottawa.



the Mycological Herbarium of the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa; and the Farlow Herbarium, Harvard University. In addition, specimens have been loaned from the Durand Herbarium, Cornell University; the Mycological Herbarium of the New York Botanical Garden; and the Mycological Herbarium of the United States Department of Agriculture.

#### THE GENUS *DERMEA*

The genus *Dermea* includes a group of inoperculate Discomycetes characterized by the hard, leathery consistency, and the dark brown to black color of the apothecia, which are erumpent through the bark of twigs and branches and occasionally of main trunks of woody plants. The asci are cylindric to cylindric-clavate, and usually eight spored. The ascospores are ellipsoid-fusiform to ellipsoid, hyaline to yellowish-brown, and continuous to tri-septate. The paraphyses exceed the asci and their tips are more or less glued together forming an epithecium. Conidia that are generally elongate-fusiform to subfiliform, pointed at the ends, and more or less curved, occur in the life history. The conidial fruiting bodies may vary considerably in form in the different species. Microconidia are usually present and are hyaline, bacillar to filiform, and often more or less curved.

The above concept of the genus arose principally from the work of the Tulasnes (1865), who made careful field observations and remarkably accurate deductions concerning the conidial relationships of several species. They considered the type of the genus to be *Dermea Cerasi* (Pers. ex Fr.) Fr. This species is one of the most frequently collected and best known *Dermeac* and, as a result, the concept of this genus has remained relatively stable as compared to that of many other genera of Discomycetes.

Most authors have used the name *Dermatea* for this genus, and considered it to date from the treatment by Fries in the *Summa Vegetabilium Scandinaviae* 1849, but Seaver and Velasquez (1933) have drawn attention to an earlier work in which Fries proposed the name *Dermea* in essentially the same sense. In order to comply with the International Rules of Nomenclature it is necessary to adopt the earlier spelling, although *Dermatea* is much better

known, more euphonious, and more correct etymologically. However, because the attainment of stability in mycological nomenclature is most desirable, and since I am of the opinion that this can be best achieved by adherence to the Rules, even at the cost of temporary inconvenience caused by unfamiliar names, I have decided, somewhat reluctantly, to adopt the name *Dermea*.

According to Article 20 of the International Rules of Nomenclature, the nomenclature of fungi other than the Uredinales, Ustilaginales, and Gasteromycetes begins with Fries' *Systema Mycologicum* 1821-32. A difference of opinion exists among mycologists as to the interpretation of this rule. Some take the view that the starting point should be taken as 1821, others that the starting point for each group should date from its appearance in the *Systema*. The citations for certain species will vary according to the viewpoint adopted. For example, *D. Cerasi* will be *D. Cerasi* (Pers. ex Pers.) Fr. if the first view is adopted, but will be *D. Cerasi* (Pers. ex Fr.) Fr. if the second is adopted. In this paper the latter method of citation has been adopted, for this seems to me to be the interpretation called for by the Rules. I am of the opinion, however, that the adoption of 1821 as the starting point would tend to simplify problems of mycological nomenclature in general.

According to the interpretation adopted here, the nomenclature of the group begins with the *Systema Mycologicum* Vol. 2 published in 1822. In this volume Fries described several species of *Dermea* including *D. Cerasi* under the genera *Cenangium* and *Tympanis*. The name *Dermea* was proposed by Fries in the *Systema Orbis Vegetabilis* in 1825 on p. 114<sup>3</sup> as follows:

*DERMEA* (Baba). Perithecium suberoso-coriaceum cum strato discigero confluent, disco demum late aperto plano. Asci distincti, fixi, persistentes. Coloratae.

Genus *Pezizis* maxime affine, H. 1. *Pezizae* coriaceae, erumpentes v. c. *P. tiliacea*, *furfuracea* &c. nec non *Cenangium Cerasi*. Disco firmo &c. Patellariam fere refert: a sequentibus ascis & sporidiis admodum distinctum apparet.

In the *Elenchus*, Vol. 2, 1828, in reviewing the *Discomycetes*, Fries dropped the genus *Dermea* but referred to it in the following note on page 20 under *Cenangium*:

<sup>3</sup> Seaver and Velasquez incorrectly gave the page citation as 343.

Aberrat. Cupula suberosa, discus plus nigrescens etc. in *C. Cerasi*, quod facile novi generis typus (*Dermca* S. O. V.), sed in praesenti distinguere superfluum duxi.

Finally in the *Summa*, p. 362, we find the following:

XXXV. *Dermatea* Fr. *Pezizae* et *Cenang.* sp.

Excipulum suberosum (coriaceumve in a), primo arcte clausum, dein ex urceolato expansum, disco (saturatius colorato) ascigero persistente, demum indurato.

a. *Encoelia*, coriaceae, ampliatae. *Midoti* affin.

1. *D. fascicularis*. S. M. II p. 75. 1-4. S. S. 291. B. p. 191.
2. *D. fissa*. l.c. 1, 2.
3. *D. furfuracea*. l. c. 1-3. S. S. 457. W. n. 2. B. p. 182\*\*\*).

b. *Dermateae genuinae*, suberosae. *Tuberculariis* affin.

4. *D. tiliacea*. l. c. 1-3. W. n. 43
5. *D. Cerasi*. S. M. II. p. 179. 1-3. S. S. 430. B. p. 211.
6. *D. Padi*. l. c. β *Lappon!* Sph. fallax. *Wahl!*
7. *D. Prunastri*. 3. W. Goth.! P. *Prunastri* β A. S.
8. *D. carpineae*. (*Ehrh.*) 1. Scan. Tubercul. fascicul. *Tod.*
9. *D. rubiginosa*. *El.* 2. p. 7. 4. *Alnus incana*. W. n. 45.
10. *D. purpurea*. (*Hedw.*) 1. *Ostrogth.*†) W. n. 46.

From the above it is evident that the choice of *D. Cerasi* as the type is correct according to the International Rules. It is one of the species mentioned in the *Syst. Orb.*, although not the first. However, Fries stated specifically in the *Elenchus* that he considered it to be the type. In the *Summa*, the first species mentioned under "*Dermateae genuinae*," *D. tiliacea*, should be considered an *Encoelia* as it is really closer to *D. fascicularis* than to *D. Cerasi*. The second species mentioned is *D. Cerasi*. Accordingly there is, therefore, no question that *D. Cerasi* can be accepted as the type of the genus. Moreover, in accordance with Article 18, Recommendation VI of the International Rules, the choice of *D. Cerasi* as the type fixes the generic name as it is commonly applied, a point that is of much greater importance to the establishment of a stable nomenclature than the original order in which the names were listed.

Upon the establishment of *D. Cerasi* as the type of the genus, the next step is to group around it those species which seem to be closely related and appear to form a phylogenetic unit. Most of the names in *Dermca* which have been based on North American material have been checked, and of the large number of fungi which

have been assigned to this genus at one time or another thirteen are considered to be true *Dermea* species. In addition, three new species are described, making a total of sixteen species recognized. Wherever possible European specimens have been examined and five species originally described from Europe have been recognized as occurring in North America. However, it has not been possible to check a number of species described from Europe and other continents.

#### THE CONIDIAL STAGE

One of the most interesting features of this genus is the variety of forms to be found in the conidial stage of the various species. The conidial fruiting body is essentially a stromatic structure containing a cavity in which the spores are produced. The stroma varies in form from an acervulus-like structure such as is found in *D. Hamamelidis* (FIG. 41) (and which might be referred to *Gloeosporium*), to a beaked pycnidium as in *D. Viburni* (FIG. 38) that has been placed in *Sphacrographium*. Other genera to which these conidial stages have been referred are *Micropera*, *Gelatinosporium*, *Sphaeronema*, *Phoma*, *Chondropodium*, *Cryptosporium*, and *Fusicoccum*. In culture all of the species tend to lose the characteristic shape of the fruiting body as found in nature, and form a more or less globose, fleshy stroma which develops one or more cavities in which spores are produced. This might be interpreted as the primitive or ancestral form of the conidial fruiting body in this genus, and the one from which the others have evolved. Among the conidial fruiting bodies as they occur in nature those of *D. balsanca* (FIG. 30) approach as closely as any to this primitive type.

This form was originally described as *Gelatinosporium abietinum* Peck, but there is no noteworthy difference between *Gelatinosporium* and the older genus *Micropera*. By a fortunate coincidence *M. Drupacearum* Lév., the type of the genus *Micropera*, is the conidial stage of *D. Cerasi*, the type of the genus *Dermea*. Therefore, I am of the opinion that, with the exception of *D. accrina* whose conidial stage is the type of *Naemosphaera* von Höhn., the conidial stages of all the species described here are best interpreted as belonging to *Micropera*. However, in this paper no at-

tempt has been made to name conidial stages which appear to be undescribed or to create new combinations in *Micropera* for those which have already been described under other generic names.

In contrast to the variability in the form of the fruiting body, the form of the conidial spore is remarkably constant. This is especially noteworthy in comparing the conidia produced in culture with those found in nature. In all of the species studied the size and shape of the conidia as produced in culture have agreed closely with those found in nature. The characters of the conidia are, therefore, very useful in species recognition, for they also exhibit characteristic differences in size and shape in different species.

It is, in fact, possible to arrange the species of *Dermca* into four more or less clear cut groups based on the size and shape of the conidia. Since each of the three species occurring on *Prunus* falls into a different group, and the fourth group consists of the single species, *D. accrina*, it is convenient to designate the groups by the names of the *Prunus*-inhabiting species as follows: the Cerasi group, the Padi group and the Prunastri group.

The Cerasi group is characterized by having conidia which are long, usually exceeding  $35\ \mu$  in length, and sharply pointed at the ends. Six species may be included in this group, *D. Cerasi* (*Micropera Drupaccarum*, FIG. 42b), *D. molliuscula* (*Gelatinosporium fulvum*, FIG. 47b), *D. balsamea* (*G. abietinum*, FIG. 54b), *D. Peckiana* (*Micropera caespitosa*, FIG. 56b), *D. Libocedri* (FIG. 57b), and *D. Viburni* (*Sphaerographium hystrixinum*, FIG. 49b). If the conidial fruiting body of *D. balsamea* is interpreted as the primitive type, those of *D. Cerasi* and *D. molliuscula* differ in having several cavities; *D. Peckiana* in having an excessive development of the basal stroma with several smaller cavities at the top; *D. Libocedri* as a somewhat reduced form in which the upper part of the stroma enclosing the cavity soon disappears; and *D. Viburni* as the most highly developed form consisting of a long-beaked pycnidium of definite form and more complex structure. The conidia differ somewhat in size and in the proportion of length to width in the different species. Those of *D. Viburni* are the most distinctive being typically much more pointed at one end than the other.

In regard to the characters of the perfect stage, the apothecia of the first three are large and conspicuous whereas in the latter

three they are much smaller; those of *D. Viburni* especially being much less conspicuous than the conidial fruiting bodies. The asci are similar in the first four species, but in *D. Libocedri* they tend to approach certain species of the Prunastri group in shape, and in *D. Viburni* they are more like those of the Padi group. It is evident that in most characters *D. Viburni* does not fit well into this group, but unless it is placed entirely by itself it seems to belong here better than in any of the other groups.

The Padi group includes the three species, *D. Padi* (*Micropera padina*, FIG. 44b), *D. bicolor* (FIG. 45b), and *D. Ariae* (*Micropera Sorbi*, FIG. 53b), in which the conidia rarely reach 35  $\mu$  in length and are usually much shorter, very narrow, and have sharply pointed ends. In this group the conidial fruiting bodies of *D. Ariae* are closest to the primitive form. Those of *D. bicolor* approach the multiloculate stroma of *D. Cerasi* whereas those of *D. Padi* are more definitely organized, cylindric to conic in shape, but scarcely beaked. The apothecia in all three species are small to medium sized with small, cylindric asci and small ascospores. Since the asci and ascospores of *D. Padi* are only slightly smaller than those of *D. Cerasi*, it is difficult to distinguish these two species on these characters. In the characters of the conidia, asci, and ascospores these three are very similar, but in color and consistency of the apothecia *D. Padi* and *D. bicolor* are like *D. Cerasi* whereas *D. Ariae* is more brownish and softer, approaching the Prunastri group in these respects.

The Prunastri group is characterized by having conidia which are relatively short, usually less than 40  $\mu$  in length, proportionately broader than in the other groups, and not as sharply pointed at the ends. It includes six species: *D. Prunastri* (*Micropera spuria*, FIG. 43b), *D. Hamamelidis* (FIG. 46b), *D. Tulasnei* (*Micropera cryptosporioides*, FIG. 55b), *D. Chionanthi* (FIG. 48b), *D. pinicola* (FIG. 51b), and *D. piccina* (FIG. 52b). The conidial fruiting body of *D. Hamamelidis* is the simplest found in the genus, consisting, as found in nature, of little more than a layer of conidiophores on a slight cushion of tissue. However, in culture the conidia are produced in a cavity in a more or less globose stroma as in other species so that it is probably best interpreted as a reduced form. The conidial fruiting bodies of *D. Tulasnei*, *D. Chionanthi* and *D.*

*piccina* are similar to the form here regarded as the primitive type, whereas in *D. Prunastri* we again find the beaked pycnidium. The conidial fruiting bodies of *D. pinicola* have not been observed in nature as yet.

The apothecia of this group are mostly small, softer in consistency, and more brownish in color than those of the other groups. However, *D. Prunastri* and *D. Hamamelidis* approach the *Cerasi* group in these respects. In general, the asci of this group tend to be proportionately broader and therefore more clavate than those of the other groups. Also, the ascospores are proportionately broader and more ellipsoid in shape. *D. Prunastri* is again an exception as its asci and ascospores are very similar to those of *D. Cerasi* and it is, in fact, almost impossible to distinguish these two species on these characters.

It is therefore evident that the three groups outlined above are not clear cut in the sense that the characters of the imperfect and perfect stages are correlated completely. In each group there are species which exhibit some of the characters of those in the other groups, and it is obvious that this would occur regardless of whether the grouping was made on the basis of some character other than the conidia. The use of the conidia as a basis for grouping the species does seem to bring together the more closely related forms.

The fourth group contains the single species *D. accrina* (*Nacmosphaera acerina*, FIG. 50b) in which the conidia differ from all other species of *Dermea* in being oblong-ellipsoid. They are similar in shape to the conidia found in the closely related genus *Pezicula*, and this raises the question of what constitutes the distinction between *Dermea* and *Pezicula*.

The habit of growth is similar in both genera, all the species being erumpent through the bark of twigs and branches of woody plants. All of the leaf-inhabiting species of which I have seen material may be definitely excluded from these genera, and probably all leaf-inhabiting species should be so excluded. In *Pezicula* the apothecia are typically bright colored, yellowish to ochraceous, and softer in consistency, i.e. more fleshy-waxy than the leathery *Dermeae*. In *Pezicula*, also, the asci are usually proportionately

broader and more clavate and the ascospores more broadly ellipsoid to oblong-ellipsoid or ovoid. Correlated with these differences are the oblong-ellipsoid conidia found in species of *Pezicula* as contrasted with the elongate-fusiform to subfiliform conidia found in species of *Dermea*.

In color and consistency *D. acerina* is typical of the genus, in fact it is darker and tougher than *D. Tulasnei*. The asci and ascospores approach the *Pezicula* type to some extent, but not more than other species in the *Prunastri* group, for example, *D. piccina*, *D. pinicola*, *D. Chionanthi*, and *D. Tulasnei*. It is, therefore, only in the shape of the conidia that this species shows a striking difference from other species of *Dermea*.

Another species which occupies a somewhat intermediate position between the two genera is *Pezicula Frangulae* (Pers. ex Fr.) Fckl. occurring on *Rhamnus* with the conidial stage *Cryptosporiopsis versiformis* (Alb. & Schw.) Wollenw. In gross appearance dried specimens of this species strongly suggest *Dermea* but, on moistening, they become lighter colored with a consistency like *Pezicula*. The asci are similar in shape to those of *D. acerina* but are, of course, distinctive in being four spored. Both the ascospores and conidia are oblong-ellipsoid as in *Pezicula*. Thus, in this species the majority of the characters seem to indicate a closer relationship to *Pezicula* than to *Dermea*. I have not seen this fungus in the fresh condition or studied it in culture, but Wollenweber (1939), who cultured it, concluded that it belonged in *Pezicula*.

Finally, the species described as *Pezicula alnicola* by Groves (1940) should be mentioned. Its apothecia are typical of *Pezicula* in color and consistency, but the conidia are of the elongate-fusiform to subfiliform type, and the asci and ascospores are more *Dermea*-like in shape than those of *D. acerina*.

On the basis of this information it is evident that it is impossible to draw a sharp dividing line between these two genera. Here, as in other groups of Discomycetes, the generic position is not determined solely by one character but rather by the sum total of characters, and there are a few species whose generic position remains more or less a matter of opinion.



## METHODS

Whenever possible, this study has been based on living material. Of the sixteen species recognized, fifteen have been studied in the fresh condition and I have personally collected thirteen of them. Morphological studies have been made from crushed mounts and freehand sections either in water, lactophenol containing dilute cotton blue, or phloxine in KOH.

Cultures were obtained from both ascospores and conidia whenever possible. Ascospore cultures are readily obtained by fastening an apothecium to the lid of a Petri dish with a drop of agar and allowing it to discharge spores on to the agar below. Single ascospore cultures of some species were made, but for the most part mass ascospore cultures were used. If fresh apothecia in good condition are chosen it is very seldom that any trouble is experienced with contaminations. As a further check tissue cultures from the interior of the apothecia were sometimes made, but usually only ascospore cultures were attempted.

In obtaining cultures from conidia the simplest method is to place the twigs in a moist chamber over night and then to pick off a fresh spore mass with a sterile needle. This can either be transferred to sterile water and loopfuls used to pour dilution plates, or the spores may be transferred directly to a tube of cooled, melted agar which is rotated to distribute the spores and then poured immediately into a Petri dish. If the twigs are not allowed to become watersoaked and freshly produced spore masses are chosen, pure cultures can be obtained without difficulty.

Cultures were grown on potato dextrose agar and on malt extract agar. Both media proved satisfactory, but on potato dextrose agar there was some tendency to produce excess mycelium and fewer conidial fruiting bodies. Accordingly, two per cent malt extract agar was used throughout.

Cultures were also grown on sterilized twigs of the host. Twigs were cut into lengths of 8-10 cm., a slit was cut in the bark at one end, and they were placed in 250 cc. or 300 cc. Erlenmeyer flasks with 25-30 cc. of water and sterilized in the autoclave at 15 lbs. pressure for 30 minutes. When cool they were inoculated by placing bits of agar and mycelium in the slit which had previously

been cut in the bark. Some flasks were stored in the laboratory at room temperature in diffuse light, others were kept in the greenhouse shaded from direct sunlight, and others were kept in the dark in a refrigerator at about 15° C. Conidial fruiting bodies were produced under all these conditions.

The study of living material furnished a basis for species concepts which proved to be invaluable in the interpretation of dried specimens, on which identifications must finally rest. Identifications have been made by comparison with types when possible or by comparison with exsiccata and published descriptions. The species of this group retain their characters well when dried and satisfactory preparations can be obtained from dried material by boiling apothecia or bits of the hymenium for about thirty seconds and then making a crushed mount in lactophenol containing dilute cotton blue.

#### CULTURAL STUDIES

Of the sixteen species described in this paper, all but one have been studied in culture. Twelve species have been cultured from both ascospores and conidia, one from ascospores only, and two from conidia only. In *D. pinicola* I failed to find the conidial stage in nature although it undoubtedly occurs, for cultures from ascospores gave rise to conidial fruiting bodies with conidia of the typical *Micropera* type. I have never collected *D. Padi* or *D. Libocedri* and in the specimens I received the apothecia failed to discharge spores. However, the nature of the association between the apothecia and the conidial fruiting bodies, and the similarity between these and the conidial stages of other *Dermea* species, leave little doubt concerning the genetic connection.

Only one species, *D. Chionanthi*, has not been seen in the fresh condition and has not been studied in culture. But in this species also a conidial stage of the *Micropera* type was observed closely associated with the apothecia in dried specimens, and it seems a reasonable assumption that this is the conidial stage.

In order to prove the genetic connection between the perfect and imperfect stages it would be desirable to complete the life history in culture using cultures originating from both ascospores and conidia. *D. balsamea* is the only species in which this has been

achieved. Apothecia were produced on sterilized twigs of both *Abies* and *Tsuga* in cultures originating both from ascospores and from conidia. However, in the other species it was considered sufficient evidence to establish the connection when cultures from both ascospores and conidia produced the same conidial stage in culture. It was observed that the form of the conidial fruiting body as produced in culture frequently differed considerably from the form found in nature but the conidia usually agreed closely in size and shape with those occurring naturally.

As well as providing evidence for the connection between perfect and imperfect stages, cultures have been of great assistance in the identification of species. For example, *D. bicolor* was first collected in the Timagami Forest Reserve in 1935 on an unidentified branch lying on the ground, but the fungus was not recognized and was carried in culture as an unknown *Dermea* until 1941 when the species was identified from a collection made at the Petawawa Forest Experiment Station and known to be on *Amelanchier*. The similarity in the cultures from the two collections led to the identification of the earlier Timagami specimen.

There has also been some confusion concerning the identity of the three species of *Dermea* occurring on *Prunus*. These are not always easily distinguished by their apothecial characters, but they can be readily distinguished in culture. Cultures of *D. Cerasi* on malt extract agar reach a diameter of about 2–3 cm, in four weeks. The colonies are white to pale buff with short, fluffy, aerial mycelium. Cultures of *D. Prunastri* grow at about the same rate or somewhat more slowly. However, they are compact, fleshy, more or less heaped up and radially furrowed, variously colored—olive to greenish, yellowish, or brownish—with short, velvety, aerial mycelium. Cultures of *D. Padi* are similar to those of *D. Cerasi* in gross appearance, but they can be distinguished at once by the much smaller conidia.

Other species in which the cultures are more or less brightly colored, varying from olive to yellowish, greenish, or brownish, are *D. Ariae*, *D. molliuscula*, and *D. piccina*. In *D. acerina* the cultures are usually bright green with a fluffy aerial mycelium but some cultures are brownish and lack the aerial mycelium.

As would be expected, in all of the species there are variations

in the cultural characters of different isolates and in the same isolates under different conditions, which make it difficult to describe them precisely in terms which would enable others to recognize them. However, conidia are usually produced readily in culture and these, combined with the appearance of the cultures, will enable the species to be identified. For example, the conidia of *D. Ariac* and *D. bicolor* are very similar but the cultures are quite distinct. On the other hand cultures of *D. bicolor* somewhat resemble those of *D. Peckiana*, but the conidia are very different.

In some species the cultures are sufficiently distinct to enable recognition of the species from their gross appearance. In *D. Viburni* the brownish, soft, fleshy cultures with irregular, lacerate margin, and almost no aerial mycelium are quite different from any of the other species. In *D. Hamamelidis* the cultures are very slow-growing, heaped up and usually deeply furrowed, tough, fleshy in consistency, whitish to brownish in color and with almost no aerial mycelium.

Although in most of the species the cultures are more or less distinctive, I consider their characters to be of secondary importance in distinguishing species of *Dermea*. Chief reliance should be placed on the characters of the asci, ascospores, conidial fruiting bodies, and conidia.

#### HOST RELATIONS AND PARASITISM

The evidence presented in this study indicates that the species of *Dermea* are, in general, specific to host. Only two species have been collected on plants belonging to more than one genus. *D. balsamea* has been collected on both *Abies* and *Tsuga*, and *D. Peckiana* on both *Ilex* and *Nemophanthus*. Seaver and Velasquez (1933) reported *D. molluscula* on both *Betula* and *Alnus* but I have seen no material on *Alnus*. A knowledge of the host on which a specimen was collected is, therefore, of great assistance in identification. It is also desirable, in collecting species of this group, to include some of the wood of the host in order that its identity may be checked in cases of doubt.

Very little is known concerning the parasitism of most species, but it would seem probable from their host specificity and their

habitat on recently killed twigs and branches that they are at least weakly parasitic. Dodge (1932) has shown that *D. balsamea* was the cause of a die-back of hemlock, and Dowson (1913) has shown that *D. Prunastri* was the cause of a die-back of greengage plums. Possibly under favorable conditions some of the species might be capable of causing damage, but the indications are that in general they are not of great economic importance.

## TAXONOMY OF THE GENUS *DERMEA*

### GENERIC DIAGNOSIS

*Dermea* Fries, Syst. Orb. Veg. p. 114. 1825.

*Cenangella* Sacc. Consp. Gen. Disc. p. 9. 1884.

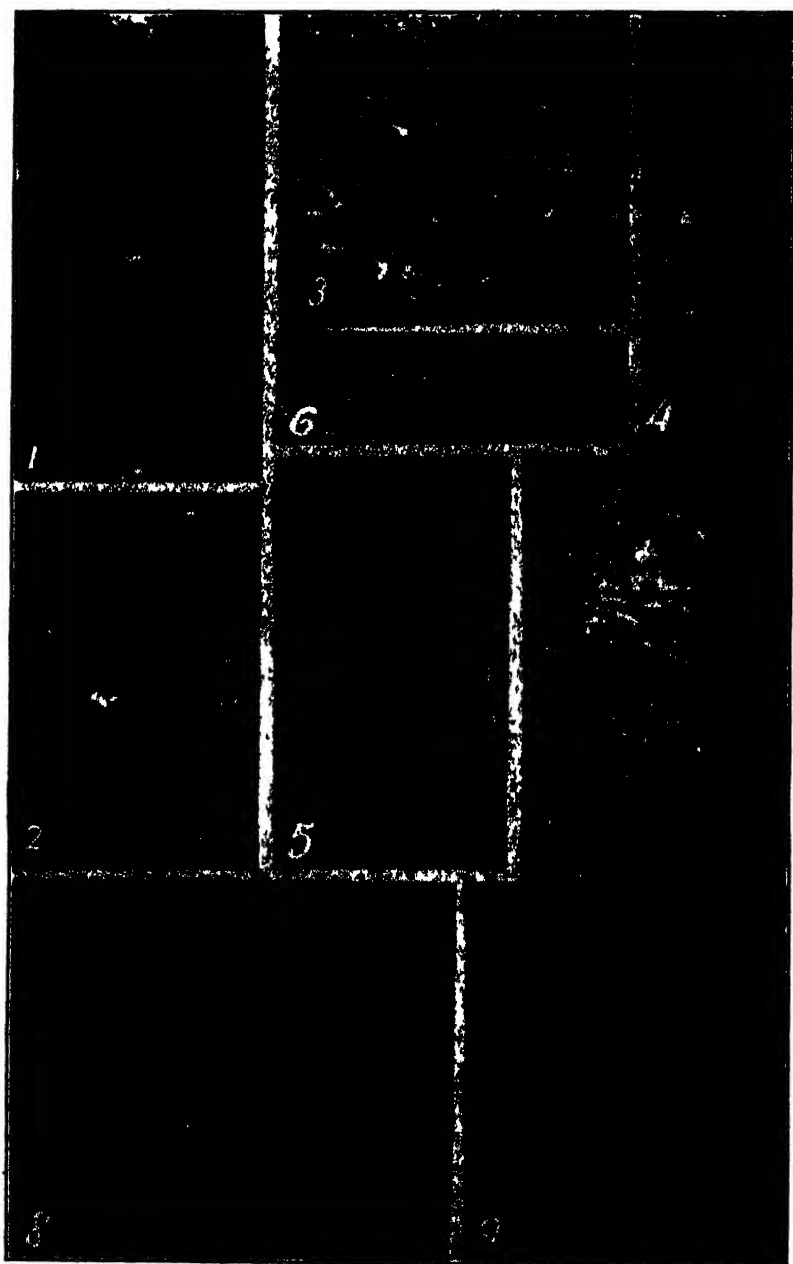
Apothecia erumpent, separate or cespitose, circular to undulate, sessile or narrowed below to substipitate, dark brown to black, hard, leathery in consistency, softer and more fleshy when moist; asci cylindric-clavate, mostly eight spored, ascospores ellipsoid to ellipsoid-fusiform, hyaline to yellowish-brown, one to several celled, paraphyses numerous, filiform, exceeding the asci and forming an epithecium; conidial fruiting bodies of various form; conidia mostly elongate-fusiform to subfiliform, pointed at the ends, more or less curved, hyaline, one to several celled; microconidia hyaline, bacillar to filiform, straight or curved, one celled.

TYPE SPECIES: *Dermea Cerasi* (Pers. ex Fr.) Fr.

### KEY TO SPECIES

1. Apothecia reaching more than 1.5 mm. in diameter.....2
1. Apothecia less than 1.5 mm. in diameter.....4
2. Asci mostly less than 13  $\mu$  in diameter, conidia mostly less than 60  $\mu$  in length, on *Prunus*.....1. *D. Cerasi*
2. Asci mostly more than 13  $\mu$  in diameter, conidia mostly more than 60  $\mu$  in length.....3
3. Apothecia more than 1 mm. in height, conidial fruiting bodies usually more than 1 mm. in diameter, conidia less than 4  $\mu$  in diameter, on *Betula*.....2. *D. molliuscula*
3. Apothecia less than 1 mm. in height, conidial fruiting bodies less than 1 mm. in diameter, conidia more than 4  $\mu$  in diameter, on *Abies* and *Tsuga*.  
3. *D. balsamea*
4. Asci four spored, apothecia yellowish when fresh, on *Rhamnus*.  
*Pezicula Frangulac*
4. Asci eight spored.....5
5. Ascospores less than 5  $\mu$  in diameter.....6

5. Ascospores more than  $5\mu$  in diameter.....9
6. Conidial stage conspicuous as beaked pycnidia, on *Viburnum*.  
6. *D. Viburni*
6. Conidial stage not beaked pycnidia.....7
7. Asci mostly more than  $10\mu$  in diameter, on *Nemophanthus* and *Ilex*.  
4. *D. Peckiana*
7. Asci less than  $10\mu$  in diameter.....8
8. Apothecia black, asci usually less than  $75\mu$  in length, rarely exceeding  $80\mu$ , on *Amelanchier*.....8. *D. bicolor*
8. Apothecia brownish, asci usually exceeding  $75\mu$  in length, on *Sorbus*.  
9. *D. Ariac*
9. Conidial stage conspicuous as beaked pycnidia.....10
9. Conidial stage not beaked pycnidia.....12
10. Conidia oblong-ellipsoid, on *Acer*.....16. *D. acerina*
10. Conidia elongate-fusiform.....11
11. Conidial fruiting bodies usually single, conidia less than  $4\mu$  in diameter, sharply pointed at ends, on *Prunus*.....7. *D. Padi*
11. Conidial fruiting bodies usually cespitose, conidia exceeding  $4\mu$  in diameter, on *Prunus*.....15. *D. Prunastri*
12. On coniferous hosts.....13
12. On frondose hosts.....15
13. Ascospores mostly less than  $14\mu$  in length, on *Picea*.....14. *D. piceina*
13. Ascospores mostly exceeding  $14\mu$  in length.....14
14. Ascospores  $13-18 \times 4-7.5\mu$ , conidia less than  $50\mu$  in length, on *Pinus*.  
13. *D. pinicola*
14. Ascospores  $15-20 \times 6-8\mu$ , conidia mostly exceeding  $50\mu$  in length, on *Libocedrus*.....5. *D. Libocedri*
15. Asci less than  $15\mu$  in diameter.....16
15. Asci mostly exceeding  $15\mu$  in diameter.....17
16. Apothecia small, scarcely reaching 1 mm. in diameter, conidia exceeding  $4\mu$  in diameter, on *Hamamelis*.....10. *D. Hamamelidis*
16. Apothecia larger, reaching 1 mm. or more in diameter, conidia less than  $4\mu$  in diameter, on *Prunus*.....7. *D. Padi*
17. Asci  $14-18\mu$  in diameter, ascospores mostly  $15-20 \times 6-8\mu$ , on *Fraxinus*.  
12. *D. Tulasnei*
17. Asci  $15-20\mu$  in diameter, ascospores  $18-25 \times 7-9\mu$ , on *Chionanthus*.  
11. *D. Chionanthi*
1. DERMEA CERASI (Pers. ex Fr.) Fr. Syst. Orb. Veg. p. 115.  
1825. (FIGS. 1, 2, 27, 42.)  
*Peziza Cerasi* Pers. Tent. disp. meth. fung. p. 35. 1797.  
*Cenangium Cerasi* Fries, Syst. Myc. 2: 179. 1822.  
*Cycledum Cerasi* Wallr. Flor. crypt. Germ. 2: 512. 1833.  
*Tympanis Cerasi* Quél. Enchir. Fung. p. 330. 1886.  
St. conid.  
*Micropera Drupacearum* Lév. Ann. Sc. nat. III, 5: 283. 1846.  
*Micropera Cerasi* Sacc. Myc. Ven. p. 160. 1873.

FIGS. 1-9. Species of *Dermocarpus*.

*Micropera Cerasi* Bon. Abh. Nat. Gesells. Hall. 8: 133. 1864.

*Micropera roseola* Lév. Ann. Sc. nat. III, 5: 283. 1846.

*Sphaeria dubia* Pers. Ic. Pict. Fung. fasc. 4: p. 48, t. 20, f. 1. 1806.

Apothecia erumpent, gregarious, separate or sometimes cespitose, with few in a cluster, sessile, narrowed below, circular to undulate, 1.0–3.0 mm. in diameter and up to 1.5 mm. in height, at first brownish to yellowish-brown, furfuraceous, finally black and glabrous, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium at first concave, becoming plane or convex, roughened, sometimes cracked, occasionally slightly umbilicate, black, olivaceous to greenish when moist, margin at first thick, raised, furfuraceous, finally glabrous and disappearing, openings of the pycnidial cavities often appearing as yellowish wrinkles around the margin; tissue of the basal stroma composed of closely interwoven hyphae with elongated cells about  $8\ \mu$  in diameter, hyaline to brownish, thick walled, often with host cells intermingled, tissue very compact below, often looser above and the cell walls thinner and darker, frequently with intercellular spaces, toward the outside the cells almost isodiametric, arranged in more or less obliquely parallel rows; subhymenium a narrow zone of closely interwoven, slender hyphae; asci cylindric-clavate, tapering below into a short stalk, eight spored,  $(75)90\text{--}120(150) \times 10\text{--}13(15)\ \mu$ ; ascospores ellipsoid-fusiform, hyaline to yellowish-brown, straight or slightly curved, one to four celled, irregularly biseriate,  $(12)15\text{--}20(25) \times (4)5\text{--}7.5\ \mu$ ; paraphyses hyaline, filiform, septate, simple or branched,  $1.5\text{--}2.0\ \mu$  in diameter, the tips slightly swollen up to  $4\ \mu$  and glued together forming a yellowish epithecium.

Conidial fruiting bodies erumpent, gregarious, very irregular in shape, circular or elongated, rounded irregularly to conical, 0.5–2.0 (3.0) mm. in length, 0.2–1.0 mm. in height, whitish to yellowish, pruinose to furfuraceous, surface wrinkled, soft, waxy, brittle, becoming more fleshy when moist, usually containing several flask-shaped, more or less lobed cavities which open irregularly and sometimes widely; tissue similar to the basal stroma of the apothecia, composed of closely interwoven, hyaline hyphae, toward the outside the cells shorter and darker, and around the cavities arranged in parallel rows; conidiophores hyaline, cylindric, septate, simple or branched, tapering to a slender tip,  $10\text{--}25 \times 2.0\text{--}2.5\ \mu$ ; conidia elongate-fusiform to subfiliform, sickle-shaped or sigmoid to almost straight, ends pointed, hyaline to faintly greenish, one or two celled,  $(35)40\text{--}60(65) \times 2.5\text{--}4.5\ \mu$ ; microconidia hyaline, filiform, almost straight or curved, one celled,  $12\text{--}23 \times 1.0\text{--}1.5\ \mu$ .



Host: *Prunus* spp. *P. avium* L.; *P. Cerasus* L.; *P. emarginata* (Doug.) Walp.; *P. nigra* Ait.; *P. pennsylvanica* (L.) f.; *P. serotina* Ehrh.; *P. virginiana* L.

EXSICCATI: Moug. & Nestl. Stirp. crypt. Vog. 494; Rab. Fung. Eur. 1023; Fuckel, Fung. Rhen. 1127; Vize Micro-fung. Brit. 386; Cooke, Fung. Brit. 659; All. & Schn. Fung. Bav. 263 (*D. Padi*); Roum. Fungi Sel. Gall. Exs. 265, 931 (*Micropera Cerasi* f. *minor*), 887 (*Micropera roseola*), 1130 (*Micropera Cerasi* f. *major*), 3173 (*Dermatella Cerasi* f. *pycnidifera*); Fungi Columb. 4942; Ellis, N. Am. Fungi 40 (*Micropera Drupacgarum*), 2812; Shear, N. Y. Fungi 94; Rel. Farl. 113; Sacc. Myc. Ital. 673.

SPECIMENS EXAMINED:<sup>1</sup> CANADA: **Nova Scotia**: Glenmont; DAOM 4630, F; DAOM 4632; DAOM 4635; DAOM 4851;—Colchester Co., JWG 797 ex LEW 1753.—**Quebec**: Cacouna, DAOM 3430, JWG 135, F;—Duchesnay, DAOM 5315, JWG 603; JWG 597;—Ile Jésus, DAOM 7682;—Tenaga, DAOM 5743;—Lennoxville, DAOM 12050, JWG 775;—Ile Perrot, F;—St. Elzéar, DAOM 3800;—St. Alphonse de Caplan, DAOM 3794, F; DAOM 3780, F.—**Ontario**: Timagami Forest Reserve, T 4385, JWG 8; JWG 28; JWG 29; T 4376, JWG 60; T 6574, JWG 172; JWG 241; DAOM 2519; JWG 493;—Toronto, T 4383, JWG 1; T 4384, JWG 3; JWG 4; T 4540, JWG 75; T 4534, JWG 80; T 4533, JWG 86;—Aurora, T 7206, JWG 96; T 4458, F;—Forester's Falls, T 4842, DAOM 3318, JWG 122;—Peta-wawa For. Exp. Stn., DAOM 4705;—Ottawa, DAOM Macoun 94; DAOM Macoun 329; Lake Rosseau, F. Harper 589.—**British Columbia**: Hastings, DAOM Macoun 35.

UNITED STATES: **Maine**: Greenville, F;—Eastport, F.—**New Hampshire**: Chocorua, F, Aug. 1918; F, Sept. 28, 1906; Shelburne, F, Sept. 1893; F, Thaxter 4427;—Intervale, F, Thaxter 3728;—Glen Ellis, F.—**New Jersey**: Willsboro Pt., F ex USDA 1380.—**Maryland**: Brookmont, JWG 694.—**New York**: Ithaca, JWG 234; F, Aug. 7, 1934, W. W. Ray;—E. Galway, F;—Alcove, F ex USDA 64103.—**Pennsylvania**: Potter Co., DAOM 5376; F, Shear 4192; F, Shear 4198.—**Michigan**: Ann Arbor, JWG 576;—Atlanta, F, April 9, 1929, D. V. Baxter.

EUROPE: **Austria**: T, F ex Barbey-Boissier 1117; T ex Barbey-Boissier 1118.—**Belgium**: F ex Herb. Crypt. Belg. 1849.—**England**: F ex Cooke Herb.—**Hungary**: F, DAOM, Magyar Flora 90; F.—**Sweden**: DAOM unnumbered.

<sup>1</sup> In listing the specimens examined the aim is to give sufficient data for the collections to be recognized by other workers. The collections are arranged geographically and cited by herbarium numbers when possible. The herbaria are indicated by code letters as follows: DAOM—Mycological Herbarium of the Division of Botany and Plant Pathology, Central Experimental Farm, Ottawa; T—University of Toronto Herbarium; F—Farlow Herbarium; NYBG—Herbarium of the New York Botanical Garden; USDA—Mycological Herbarium of the U. S. Department of Agriculture; LOO—L. O. Overholts; LEW—L. E. Wehmeyer; JWG—J. W. Groves. Different collections are separated by semicolons, duplicate collections by commas.

A number of species of *Dermea* on *Prunus* have been described and some confusion has arisen concerning their identity. Cultural studies have shown that it is possible to distinguish at least three species in North America. The characters which most clearly separate them are the size and shape of the conidia.

They have been identified as *D. Cerasi* (Pers. ex Fr.) Fr., *D. Prunastri* (Pers. ex Fr.) Fr., and *D. Padi* (Alb. & Schw. ex Fr.) Fr. In *D. Cerasi* (FIG. 42b), the conidia are mostly  $40-60 \times 2.5-4.5 \mu$ , and sharply pointed at the ends. The conidial fruiting bodies consist of fleshy stromata usually containing several cavities, and the apothecia are large, usually exceeding 1 mm. and frequently more than 1.5 mm. in diameter. They usually occur in clusters. In *D. Padi* (FIG. 44b), the conidia are similar in shape to those of *D. Cerasi* but much smaller,  $20-30 \times 2.5-4.0 \mu$ . The conidial fruiting bodies consist of hard, horny, rostrate stromata, usually containing a single cavity, and the apothecia are smaller, mostly about 1.0 mm. in diameter and mostly occurring singly. In *D. Prunastri* (FIG. 43b), the conidia measure  $20-30 \times 4-7 \mu$ , about the same length as those of *D. Padi* but thicker and not as sharply pointed at the ends. The conidial fruiting bodies are usually caespitose, long-rostrate, very hard and horny in consistency, and contain a single cavity. The apothecia are also usually in clusters, more brownish in color than those of the other two species, and usually less than 1 mm. in diameter. The characters of the asci and ascospores are very similar in all three species. As noted above in the discussion of cultural characters, the cultures of *D. Prunastri* are very different from the other two.

Unfortunately the types of these species have not been available and it has been necessary to rely, for the most part, on published descriptions in order to identify them. *D. Cerasi* and *D. Prunastri* were both first described by Persoon (1797) under *Pesisa* and were both recognized by Fries (1822) under *Cenangium*. Both Persoon (1822) and Fries (1822) cited the specimen in Moug. & Nestl. Stirp. Crypt. vog. 494 in their accounts of this species therefore, this exsiccatus should be regarded as authentic. A specimen in the Farlow Herbarium under this number and labelled *Pesisa Cerasi* Pers. was examined and good material of both perfect and

imperfect stages was present. The identification of *D. Cerasi* may, therefore, be considered as based on this specimen.

Neither Persoon nor Fries cites any specimens of *D. Prunastri*, but both emphasize the character of the conidial fruiting bodies in their descriptions. As Tulasne (1865) pointed out, they believed that these represented the young stages of the apothecia and would eventually expand to form the disc. Tulasne realized that these fruiting bodies and the apothecia were different states of the same fungus. His description fits our fungus well. He noted that the asci and ascospores were indistinguishable from those of *D. Cerasi* but that the apothecia were smaller. One discrepancy in his account is noted in that he says the conidia were scarcely more than  $3.5\ \mu$  in diameter whereas I find them to be mostly  $4-7\ \mu$ . He found the conidia of *D. Padi* to be  $3.5\ \mu$  thick also and this measurement agrees with mine. Possibly he observed immature conidia of *D. Prunastri*.

*D. Padi* was originally described by Albertini and Schweinitz (1805) as a variety of *D. Cerasi*. They noted that it was often solitary and described the conidial fruiting bodies, which they believed to be young apothecia. The fungus was similarly treated by Fries (1822) but later (1849) raised to specific rank. Tulasne (1865) could not find any difference between it and *D. Cerasi* in the apothecial stage, but noted the difference in the form of the pycnidia and in the size of the conidia. Karsten (1871) recorded the same observations. Rehm (1889) had evidently not seen good material and was very doubtful of this species and later (1912) made the statement that it was not notably different from *D. Prunastri*. Nannfeldt (1932) recognized all three species in the traditional sense but Seaver and Velasquez (1933) considered both *D. Prunastri* and *D. Padi* to be synonyms of *D. Cerasi*.

*D. Padi* seems to be the least well known of the three species. I have not collected it and have not succeeded in obtaining ascospore cultures. Cultures were obtained from the conidia in one specimen sent by Dr. W. L. White. These cultures resembled cultures of *D. Cerasi* in gross appearance but have produced a conidial stage with the small conidia of *D. Padi*. Because of the difference in the conidia, *D. Padi* should be regarded as a distinct species.

Other species that have been reported on *Prunus* are *Cenangium*

*hypodermium* (DC.) Sacc., *Dermea vernicosa* (Fckl.) Rehm, *D. olivacea* Otth, *D. Houghtonii* Phill., *D. pulcherrima* Fckl., and *Dermatella hortorum* Kirschst.

*Cenangium hypodermium* was originally described by De Candolle (1815) as *Peziza hypodermium* and was transferred to *Cenangium* by Saccardo (1889). Saccardo had apparently not seen any specimens and questioned whether it was really distinct from *D. Cerasi*. However, De Candolle apparently knew both *D. Cerasi* and *D. Prunastri* and considered his *Peziza hypodermium* to be something different. His description of *D. Cerasi* agrees very well with the modern concept of this species, but his description of *P. hypodermium* does not. It is probably a different fungus but its identity is not clear. The description is suggestive of a *Tympanis* and a species of *Tympanis* which is at present without a valid name occurs on *Prunus*. It was described by Rehm (1889) as *Tympanis Prunastri* (Fckl.) since he found it in the specimen of Fuckel Fung. Rhen. 1126 labelled *Cenangium Prunastri*. However, this combination had already been used by Wallroth (1833) for *Dermea Prunastri* and so was not available for the *Tympanis*. Furthermore, it is evident that Fung. Rhen. 1126 must have been a mixture of two fungi for Fuckel's description is clearly of the *Dermea* and Rehm unquestionably saw a *Tympanis*. Nevertheless, according to Article 56 of the International Rules, *T. Prunastri* Rehm is a synonym of *Dermea Prunastri*.

*D. vernicosa* (Fckl.) Rehm is a very doubtful species. Fuckel (1870) based his original description on the specimen in Fung. Rhen. 2072 which was said to consist of immature apothecia and a conidial stage which, from the description, might be either a microconidial form or the imperfect stage of a *Tympanis*. Fuckel stated that the fungus was close to *Cenangium Cerasi*  $\beta$  *Padi* but appeared to think it different because of the conidial stage. I have examined the specimen of Fung. Rhen. 2072 in the Farlow Herbarium. There were a few immature apothecia which would not be referred to *Dermea*, and some small black pycnidia with hyaline, one celled, cylindric to ellipsoid conidia  $4-6 \times 2-3 \mu$ . It is not the microconidial stage of a *Dermea*, but might possibly be poor material of the conidial stage of a *Tympanis*.

Rehm (1889) published a description of *D. vernicosa* based on a

specimen which he later (1912) stated was actually *D. Prunastri*. The description by Saccardo (1889) is evidently based on Rehm's description. Thus apparently no one has ever seen mature apothecia of this species.

*D. olivacea* Otth, described in 1868, is known to me only through the description in Saccardo (1899). The description is suggestive of a *Dermea* but without specimens it is impossible to say whether it is a distinct species or a synonym of one of the three species recognized here.

*Dermatella hortorum* Kirschst. was originally described as *Dermea olivacea* by Kirschstein in 1906 but later (1936) was given a new specific name since he recognized the priority of Otth's name, and was transferred to *Dermatella* because he observed four-septate ascospores. No specimens of this fungus have been seen but, from the description, the asci and ascospores are broader than any of the *Dermea* species I have recognized on *Prunus*. It should be compared with *Pezicula plantarium* Wollenweber (1939).

*Dermea pulcherrima* was described by Fuckel (1873) and does not appear to have been recognized since. It seems probable that it was based on unusually large apothecia of *D. Cerasi*.

*D. Houghtonii* Phill. is a *Pezicula* and is distinct from *P. plantarium* Wollenw.

The description of *Scleroderris Padi* Rostr. (Saccardo, 1906) suggests a *Dermea* but no material has been available for comparison.

2. *DERMEA MOLLIUSCULA* (Schw.) Cash, Mycologia 29: 304. 1937. (FIGS. 21, 39, 47.)

*Cenangium molliusculum* Schw. Syn. Fung. Amer. Bor. p. 239. 1832.

St. conid.

*Gelatinosporium fulvum* Peck, Ann. Rep. N. Y. St. Mus. 38: 97. 1885.

Apothecia strongly erumpent, scattered, separate or in clusters of about 2-6, circular, sinuate, or distorted by crowding and sometimes more or less laterally fused, sessile to substipitate, 1-3 mm. in diameter, 1-2 mm. in height, "ochraceous tawny" or "tawny" (R) to almost black, usually slightly furfuraceous to glabrous,

hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium at first concave, becoming strongly convex, dark olivaceous-brown to black, greenish when moist, sometimes cracked, at first with a thick, raised, yellowish-brown margin which later disappears; tissue of the basal stroma pseudoparenchymatous, composed of hyaline to brownish, irregular cells 6–12  $\mu$  in diameter becoming more elongated above, the central part of the stalk compact, sometimes looser above, composed of closely interwoven, thick-walled hyphae about 5  $\mu$  in diameter, curving toward the outside, forming a darker, pseudoparenchymatous excipulum of thick-walled cells about 6–10  $\mu$  in diameter; subhymenium a narrow zone of closely interwoven hyphae about 3–4  $\mu$  in diameter; asci cylindric-clavate, tapering toward the base, eight spored, (85)100–120(150)  $\times$  12–15  $\mu$ ; ascospores narrow-ellipsoid to subfusiform, hyaline, becoming yellowish, straight or slightly curved, one to four celled, irregularly biseriate to uniseriate, (13)15–20(22)  $\times$  4–7  $\mu$ ; paraphyses hyaline, filiform, septate, simple or branched, 1.5–2.0  $\mu$  in diameter, the tips slightly swollen, embedded in a yellowish matrix and forming a dark epithecium.

Conidial stromata erumpent, gregarious, transversely elongated or almost circular, 1–4 mm. in diameter, 0.5–1.0 mm. in height, slightly furfuraceous, "ochraceous-tawny" to blackish, waxy-fleshy in consistency, usually containing several more or less lobed, flask-shaped cavities which tear open irregularly and sometimes very widely; tissue at the base and around the outside of the stroma similar to that of the apothecia, around the cavities composed of ascending, more or less parallel hyphae; conidiophores hyaline, cylindric, septate, simple or branched, 15–30  $\times$  1.5–2.0  $\mu$ , conidia hyaline or pale yellowish, subfiliform, ends pointed, sickle-shaped or sigmoid to almost straight, one to four celled, 50–75  $\times$  2.5–3.5  $\mu$ , microconidia hyaline, bacilliform, straight or slightly curved, one celled, 7–12  $\times$  1.0–1.5  $\mu$ .

Host: *Betula* spp., commonly *B. lutea* Michx.

SPECIMENS EXAMINED: Type: Durand Herbarium 3933. Ex Herb. Schweinitz.

CANADA: Nova Scotia: N. Halton, DAOM 4694, JWG 552;—Colchester Co., JWG 514 ex LEW 1287a.—Quebec: Duchesnay, DAOM 5317, JWG 599; F ex USDA 71031;—Old Chelsea, DAOM 2595, JWG 440, F;—Burnet, DAOM 3918, F.—Ontario: Timagami Forest Reserve, T 3525, JWG 46; JWG 186; JWG 193;—Toronto, T 6773, JWG 278;—L'Etawawa For. Exp. Stn., DAOM 7339.

UNITED STATES: New Hampshire: Randolph, T ex Herb. NYBG as *D. Betulac*.—New York: Holl Pond, JWG 532.—Pennsylvania: Lycoming Co., JWG 656.

This species was first described by Schweinitz (1832) but does not seem to have been very frequently collected and is not well known. Seaver and Velasquez (1933) described and illustrated it under the name *Dermea Betulae* Rehm, but, as pointed out by Groves (1940), this was a misdetermination since *D. Betulae* Rehm is a *Pezicula*. Cash (1937) transferred it to *Dermea*.

The large, strongly erumpent, cespitose apothecia are somewhat similar to those of *D. Cerasi*, but are usually more or less grown together laterally and the outlines of the apothecia are indistinct. The asci are mostly broader than those of *D. Cerasi*. The conidial fruiting bodies are also very similar to those of *D. Cerasi*, consisting of a fleshy stroma containing several flask-shaped cavities, but differ in the ochraceous color. The conidia are similar in shape but longer and slightly narrower.

*Dermea fusispora*, also described as occurring on *Betula* by Ellis and Everhart (1893), is quite a different fungus and does not belong in *Dermea*. A part of the type in the Durand Herbarium 7370 has been seen. The apothecia have somewhat the gross appearance of a *Pezicula* but the hyaline, subfiliform, curved ascospores  $18-30 \times 2-4 \mu$  exclude it from this genus also. I have collected this fungus twice in the Timagami Forest Reserve and again at Duchesnay, Que., at the Mycological Society Foray held there in 1938. Cultures were obtained from the ascospores but the fungus has never produced any conidial stage in culture and none has been found in nature.

Rehm (1912) stated that *D. fusispora* was a synonym of *D. rosella* Rehm which was originally described as occurring on *Quercus*. He cited the specimen in Jaap Fung. Sel. 257a, b, which is on *Betula* and correctly identified as *D. fusispora*. The type of *D. rosella* has not been seen, but the description fits and if Rehm has correctly identified the Jaap specimen with *D. rosella* there is no question that *D. fusispora* should be considered a synonym.

A still earlier name for the same fungus is *Niptera citrinella* originally described by Rehm (1881) as occurring on *Alnus* and transferred to *Pezicula* by Rehm (1912). In the original description Rehm cited the specimen in Rehm Ascom. 262, which should evidently be regarded as the type. Through the kindness of Mr. E. W. Mason slides of this specimen were examined and

FIGS. 10-14. Species of *Dermea*.



later another specimen of the same exsiccatus was seen at the Farlow Herbarium. These agreed with *D. fusispora* and, therefore, *D. fusispora* Ell. & Ev. and *D. rosella* Rehm should be considered as synonyms of *Niptera citrinella* Rehm. The generic position of the fungus is uncertain but it does not belong in either *Dermia* or *Pezicula*.

3. *DERMEA BALSAMEA* (Peck) Seaver, *Mycologia* 24: 42. 1932.  
(FIGS. 8, 9, 30, 54.)

*Cenangium balsameum* Peck, N. Y. St. Mus. Ann. Rep. 38: 101. 1885.

*Cenangium balsameum* Peck var. *abietinum* Peck, N. Y. St. Mus. Ann. Rep. 43: 40. 1890.

St. conid.

*Gelatinosporium abietinum* Peck, N. Y. St. Mus. Ann. Rep. 25: 84. 1873.

Apothecia erumpent, gregarious, mostly separate, sometimes cespitose with 2-4 in a cluster. sessile, slightly narrowed below, circular or undulate, 1-2.5 mm. in diameter, 0.4-0.8 mm. in height, at first yellowish to brownish, furfuraceous, finally black and glabrous, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium at first concave, then plane or slightly convex, often umbilicate, roughened and sometimes cracked, light brown to olivaceous brown or black, more greenish when moist, margin at first raised, yellowish, furfuraceous, later black and glabrous, finally disappearing; tissue of the basal stroma compact, pseudoparenchymatous, composed of almost isodiametric to somewhat elongated cells about 8-12  $\mu$  in diameter, hyaline to slightly yellowish and grown together, toward the outside arranged in obliquely parallel rows and smaller, about 5-8  $\mu$  in diameter, in the upper central part more elongated and more loosely interwoven; subhymenium a narrow zone composed of slender, hyaline, closely interwoven hyphae; asci cylindric-clavate, tapering into a more or less elongated stalk, eight spored, (90)100-130(150)  $\times$  (12)14-16  $\mu$ ; ascospores ellipsoid-fusiform, hyaline or slightly yellowish, one to four celled, straight or slightly curved, irregularly biseriate to sub-uniseriate, (18)20-30(35)  $\times$  (5)6-8(10)  $\mu$ ; paraphyses hyaline, filiform, septate, usually much branched, 1.5-2.0  $\mu$  in diameter, the tips glued together forming a yellowish epithecium, and only very slightly or not at all swollen.

Conidial fruiting bodies erumpent to subimmersed, gregarious to scattered, rounded to cylindric or subconic, 0.5-1.0 mm. in diam-

eter, 0.2–0.5 mm. in height, yellowish or olivaceous to black, furfuraceous to glabrous, tearing open irregularly and widely at the top, brittle, waxy in consistency, more fleshy when moist, usually containing a single, simple or more or less lobed cavity, occasionally with more than one; tissue of the basal stroma compact, composed of closely interwoven hyphae, the cells variable in size and with the walls more or less grown together, the tissue surrounding the cavity composed of an outer zone of more or less parallel to slightly interwoven, ascending hyphae, a middle zone of closely interwoven hyphae with darker walls, and an inner zone of hyaline, interwoven hyphae from which the conidiophores arise; conidiophores hyaline, septate, sometimes branched, tapering to a slender tip,  $15\text{--}25 \times 2.0\text{--}2.5 \mu$ ; conidia elongate-filiform, pointed at the ends, hyaline to pale greenish yellow, one to four celled, usually curved, sickle-shaped to sigmoid, sometimes almost straight,  $(50)60\text{--}75(90) \times 4\text{--}5 \mu$ ; microconidia hyaline, filiform, straight or curved, one celled,  $11\text{--}22 \times 1.0\text{--}1.5 \mu$ .

Host: *Abies balsamea* (L.) Mill., *Tsuga canadensis* (L.) Carr.

EXSICCATI: Rel. Farl. 102.

SPECIMENS EXAMINED: Type. Durand Herbarium 6111.

CANADA: **Nova Scotia:** on *Abies balsamea*, Colchester Co., JWG 513 ex LEW 2072; T, LEW 1082;—Glenmont, DAOM 3977;—Truro, T, LEW 1791;—on *Tsuga canadensis*, JWG 799 ex LEW 1792.—**Quebec:** on *Abies balsamea*, Burnet, JWG 121, F; DAOM 3320;—Duchesnay, DAOM 5309, JWG 618.—Ile Jésus, DAOM 7342;—on *Tsuga canadensis*, Burnet, DAOM 2680, JWG 442;—Kingsmere, JWG 734.—**Ontario:** on *Abies balsamea*, Timagami Forest Reserve, T 3523, JWG 45; T 3527, JWG 18; T 3528, JWG 43; T 4305, F; T 4306, JWG 36, DAOM 4282; T 4386, JWG 10; T 4388, JWG 15; T 4389, JWG 16; T 4390, JWG 24; T 6591, JWG 163; T 7923, F; JWG 20; JWG 32; JWG 51; JWG 633 ex Darker 2199; DAOM 2532;—Muldrew L., F, White 3123;—Petawawa For. Exp. Stn., DAOM 4718; DAOM 7319;—Cash L., DAOM 5954;—on *Tsuga canadensis*, Toronto, T 4372, JWG 63; T 4535, JWG 76; T 4550, F; T 4834, JWG 133; T 6561, JWG 281; T 6566, F; JWG 87.

UNITED STATES: **New Hampshire:** on *Abies balsamea*, Shelburne, F Sept. 1891;—on *Tsuga canadensis*, Chocorua, F Sept. 25, 1909; F Aug. 20, 1917.—**Maine:** on *Abies balsamea*, Popham Beach, F July 31, 1933.—**Virginia:** on *Tsuga canadensis*, Shenandoah Nat. Park, F, White 3599.—**Pennsylvania:** on *Abies balsamea*, Siglerville, JWG 444 ex LOO 19019; on *Tsuga canadensis*, Huntingdon Co., DAOM 1954.

*Dermea balsamea* was first described by Peck (1885) as *Cenangium balsamcum*, occurring on *Abies*. Later Peck (1890) described a collection on *Tsuga* as a variety, *C. balsamcum* var. *abietinum*. Here he noted its association with the conidial fungus

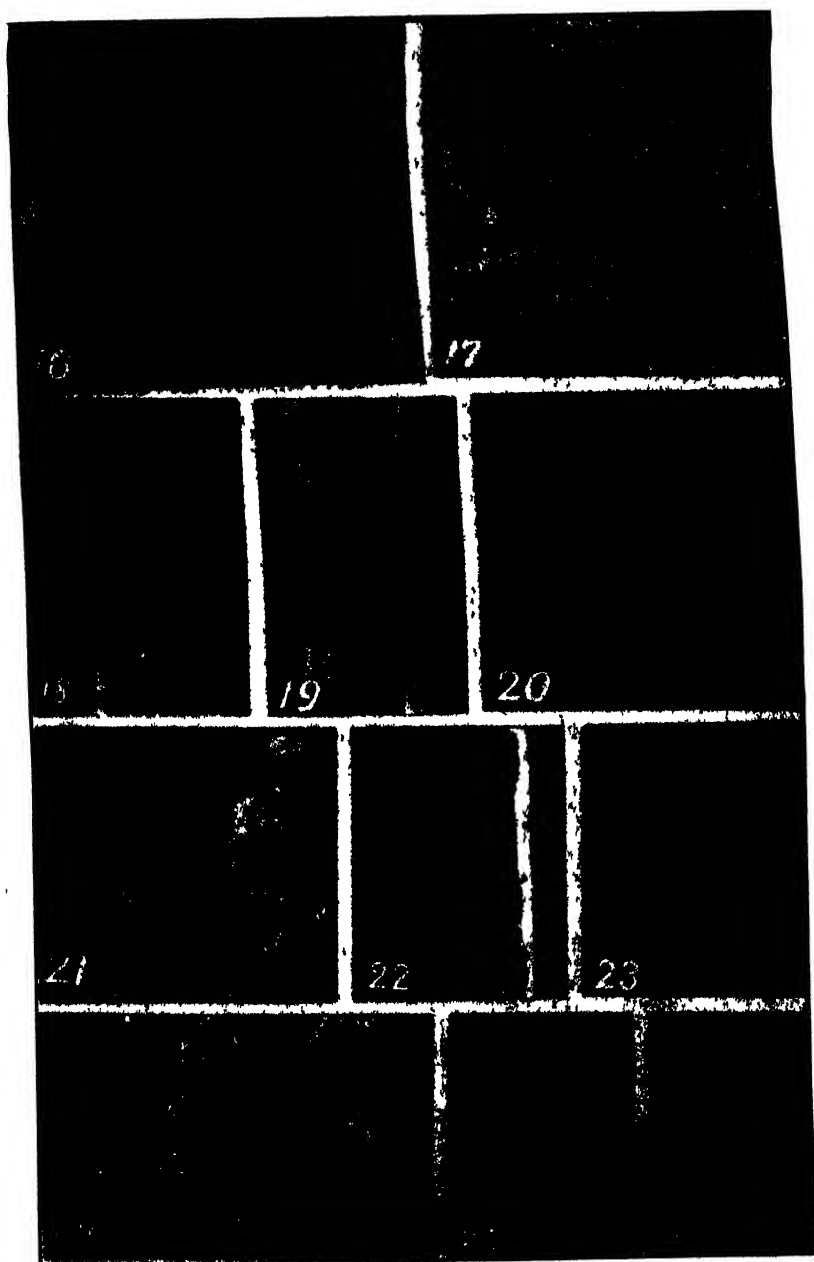
which he had described much earlier (1873) as *Gelatinosporium abietinum*, and on which he had based the genus *Gelatinosporium*. Several collections on both *Abies* and *Tsuga* have been cultured from both ascospores and conidia, and no difference has been found which would appear to justify the maintenance of the form on *Tsuga* as a separate variety. Dodge (1932) found this species associated with a die-back of *Tsuga* and established the genetic connection of the perfect and imperfect stages by means of cultural studies. Dodge's fungus was identified by Seaver who transferred it to *Dermea*.

No difference worthy of generic rank appears to exist between *Gelatinosporium abietinum*, the type of the genus *Gelatinosporium*, and *Micropera Drupaccarum*, the type of the genus *Micropera*. Since *Micropera* is the older name, the genus *Gelatinosporium* should be regarded as a synonym of *Micropera*.

*D. balsamea* is one of the larger species of *Dermea*, the apothecia sometimes exceeding 2 mm. in diameter. It can be distinguished from *D. Cerasi* and *D. molliniscula*, the other two large species, by its occurrence on *Abies* and *Tsuga* and the apothecia usually occurring singly or in small clusters of two or three. The asci tend to be somewhat broader and the ascospores slightly larger than either of the other two but the sizes overlap. The conidia are mostly longer than those of *D. Cerasi* and broader than those of *D. molliniscula*. The conidial fruiting bodies usually contain only a single cavity and are smaller and more pycnidium-like than those of either of the other two species.

It is not known whether or not this fungus occurs in Europe, but as pointed out by Dodge (1932), *Micropera Abietis* Rostr., from its description, seems to be very close to and perhaps identical with *Gelatinosporium abietinum*. The description of *D. abietinum* Vel. suggests *D. balsamea* but the figure shows an apothecium with a more pronounced stipe and ascospores that are more ovoid in shape than those of *D. balsamea*.

As noted above, *D. balsamea* is the only species of *Dermea* that has produced apothecia in culture. They have been obtained on sterilized twigs of both *Abies* and *Tsuga* in cultures originating from both ascospores and conidia. These apothecia produced asci and ascospores typical of those found in nature and the ascospores,



FIGS. 16-26. Species of *Dermea*.

on germination, gave rise to cultures similar in appearance to those obtained from nature.

4. *DERMEA PECKIANA* (Rehm) Groves, *Mycologia* 29: 67. 1937.  
(FIGS. 18, 26, 35, 56.)

*Cenangium Peckianum* Rehm, *Ann. Myc.* 13: 3. 1915.

St. conid.

*Sphacronema stellatum* Ellis, *Bull. Torrey Club* 6: 107. 1876.

*Sphaerographium stellatum* Sacc. *Syll. Fung.* 3: 598. 1884.

*Micropera Nemopanthis* Peck, *Ann. Rep. N. Y. St. Mus.* 46: 109. 1893.

*Micropera stellata* Jacz. *Nouv. Mém. Soc. Imp. Natur. Moscou* 15: 366. 1898.

Apothecia arising from the old conidial stroma, cespitose, crowded, up to 15 in a cluster, about 0.3–0.8 mm. in diameter, and the clusters up to 1 mm. in height, circular or undulate, slightly narrowed below, dark brown to black but the basal stroma pale yellowish, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium at first concave, becoming plane or convex, dark brown to black, slightly roughened, with a brownish margin which is at first raised and more or less infolded, later almost disappearing; tissue of the basal stroma compact, pseudoparenchymatous, composed of hyaline, thick-walled cells about  $8-20 \times 5-10 \mu$ , arranged in more or less vertically parallel rows, curving obliquely toward the outside where the cells are smaller, more isodiametric and with thicker and darker walls; subhymenium composed of slender, closely interwoven hyphae; asci cylindric-clavate, tapering to a slender stalk, eight spored ( $65-75-90(110) \times 9.5-12.5 \mu$ ; ascospores ellipsoid-fusiform, hyaline to pale yellowish, straight or slightly curved, one to two (to four?) celled,  $(10)12-18(23) \times (3)4-6 \mu$ ; paraphyses hyaline, filiform, septate, simple or branched,  $1.5-2.0 \mu$  in diameter, the tips swollen to  $3-5 \mu$  and glued together forming a yellowish epithecium.

Conidial stromata erumpent, rounded, verruciform, often somewhat capitate, usually thickly scattered, circular to more or less transversely elongated, 0.5–2.0 mm. in diameter and up to 1 mm. in height, upper surface uneven and wrinkled around the openings of the cavities, pale yellowish below to black on top, often with a dark vinaceous color when fresh, leathery to fleshy in consistency, softer than the apothecia; pycnidial cavities numerous in the upper part of the stroma, sometimes becoming more or less confluent, ovoid to more or less irregular in shape, opening irregularly and sometimes

very widely; conidiophores hyaline, cylindric, septate, sometimes branched,  $20-40 \times 2.0-2.5 \mu$ , tapering to a slender tip on which the spores are borne; conidia hyaline, elongate-fusiform to subfiliform, sickle-shaped or sigmoid, sometimes almost straight, ends pointed and usually one end more attenuated than the other, one or two celled,  $(25)40-55(60) \times 2.5-4.5 \mu$ , emerging in grayish masses which often show a dark vinaceous color, microconidia hyaline, filiform, straight or curved, one celled,  $8-13 \times 1.5-2.0 \mu$ .

Host: *Nemopanthus mucronata* (L.) Trel., *Ilex verticillata* (L.) Gray.

EXSICCATI: Ell. N. Am. Fung. 3042, Type; 2170, (*Sphaconema stellatum*); Fung. Columb. 332.

SPECIMENS EXAMINED: CANADA: **Nova Scotia**: on *Nemopanthus mucronata*, Oxford, DAOM 3784, JWG 497.—**Quebec**: Duchesnay, DAOM 5300, JWG 613;—St. Elzéar, DAOM 3781;—Eardley, DAOM 4682; DAOM 4685, F;—Ile Perrot, DAOM 7685; on *Ilex verticillata*, Burnet, DAOM 3976; JWG 587.—**Ontario**: on *Nemopanthus mucronata*, Timagami Forest Reserve, T 4368; T 4467; T 4468; T 4469; T 4470; T 4471; T 6576; T 6578, JWG 257; T 6592, JWG 232; T 7930, F; T 7931; T 8438; DAOM 2552; JWG 166; JWG 201; JWG 199; JWG 248;—Petawawa For. Exp. Stn., DAOM 7343, JWG 721; DAOM 7936; JWG 772;—Wilcox L., T 6926;—Parry Sound, T 6933;—Brant Co., T 7929;—on *Ilex verticillata*, Timagami Forest Reserve, T 4511; T 5071, JWG 143; T 7931, F; T 8439; T 8444; JWG 428;—Parry Sound, T 6953, JWG 286, F.

UNITED STATES: **Michigan**, on *Ilex verticillata*, Ypsilanti, T ex Univ. Mich. Crypt. Herb.

*D. Peckiana* was first described by Rehm (1915) as *Ccnangium Peckianum* based on the specimen in Ellis N. Amer. Fung. 3042. It was transferred to *Dermea* by Groves (1937) and the genetic connection with the conidial stage was then established.

In nature this fungus is frequently found closely associated with *Durandiella Nemopanthis* (Peck) Groves, the fruiting bodies often occurring intermingled on the same twigs. The apothecia of the *Dermea* can be distinguished in gross appearance by their more regular outline and dark brown color. The apothecia of the *Durandiella* are usually very undulate and black, and are also tougher in consistency. The two fungi can be distinguished very easily microscopically by the ascospores which are ellipsoid-fusiform in the *Dermea* and filiform in the *Durandiella*.

The nomenclature of the conidial stage was discussed by Groves (1937). It is quite distinct from all other species of *Micropera*

studied by reason of the excessive development of the basal stroma with several cavities developing in the upper part. The apothecia appear to arise from the old conidial stroma and in their habit of growth are distinct from other *Dermea* species. No difference worthy of specific rank could be detected between the forms on *Nemophanthus* and *Illex*.

*Dermea olivacea*, described by Ellis (1876) as occurring on *Illex*, is a distinct species which is more closely allied to *Pezicula* than to *Dermea*. Through the kindness of Dr. F. J. Seaver it was possible to examine the type. The apothecia are about the same size as those of *D. Peckiana*, but are less cespitose, a little lighter colored, and softer in consistency. It can readily be distinguished from *D. Peckiana* by the size of the asci,  $110-135 \times (22)26-33(36) \mu$ , and the ascospores,  $(20)25-32(38) \times (9)11-13(15) \mu$ . I have not collected this fungus or studied it in culture, but from the specimens examined it is a better *Pezicula* than *Dermea*. However, the name is invalid as it is a later homonym of *D. olivacea* Otth.

##### 5. *Dermea Libocedri* n. sp. (FIGS. 7, 31, 57.)

Apotheciis erumpentibus, gregariis, solitariis vel 2-4 congregatis, sessilibus, versus basim leviter attenuatis, orbicularibus vel undulatis, 0.3-0.5 mm. diam., 0.2-0.3 mm. altis, brunneis vel atris, coriaceis vel corneis, in humido carnosio-coriaceis; hymenio concavo vel plano, atro, margine initio elevato, brunneo, dein evanescente; hypothecio pseudoparenchymatico; ascis cylindraceo-clavatis, octosporis,  $75-100 \times (12)14-17 \mu$ ; ascosporis ellipsoideo-fusiformibus, hyalinis, rectis vel leviter curvulis, continuis vel triseptatis,  $15-20 \times 6-8 \mu$ ; paraphysibus hyalinis, filiformibus, simplicibus vel ramosis,  $1.5-2.0 \mu$  diam. apice ad  $3-4 \mu$  incrassatis, epithecium formantibus.

Apothecia erumpent, gregarious, separate or in small clusters of two to four, sessile, slightly narrowed below, circular to slightly undulate, 0.3-0.5 mm. in diam., 0.2-0.3 mm. in height, dark brownish black to black, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium concave to plane, black, rough, with a thick, brownish, raised margin which later disappears; tissue of the basal stroma compact, pseudoparenchymatous, composed of hyaline, thick-walled cells about  $4-7 \mu$  in diameter, almost isodiametric to slightly elongated, arranged in more or less vertically parallel rows, curving obliquely toward the outside where the cells are slightly brownish and thicker walled; subhymenium indistinct; asci cylindric-clavate, short-stalked, eight spored,  $75-100 \times (12)14-17 \mu$ ; ascospores ellipsoid-fusiform, hyaline, one to four



FIGS. 27-34. Species of *Dermea*.



celled, straight or slightly curved, biserial above to uniserial below,  $15-20 \times 6-8 \mu$ , paraphyses hyaline, filiform, simple or branched,  $1.5-2.0 \mu$  in diameter, the tips swollen to  $3-4 \mu$  and forming an epithecium.

Conidial fruiting bodies erumpent, separate, black, glabrous, minute,  $0.2-0.3$  mm. in diameter and about the same in height, rounded to subcylindric, opening at the tip, similar in consistency to the apothecia, containing a single oval or slightly lobed cavity lined with conidiophores, the walls surrounding the cavity similar in structure to the tissue of the apothecia, basal stroma about  $15-30 \mu$  in thickness, pseudoparenchymatous, similar to the apothecia; conidiophores hyaline, cylindric, pointed at the tip, simple or branched near the base, continuous, occasionally septate,  $20-30 \times 2.5-3.5 \mu$ ; conidia elongate-filiform, hyaline, sickle-shaped or sigmoid, pointed at the ends, one to four celled,  $42-65 \times 4-6 \mu$ ; microconidia hyaline, filiform, one celled, straight or curved, ends not pointed,  $10-18 \times 1.0-1.5 \mu$ .

Host: *Libocedrus decurrens* Torr.

SPECIMENS EXAMINED: JWG 691, Darlingtonia, Del Norte Co., Calif. Coll. H. E. Parks. Nov. 21, 1939. Type.

This species is known only from a single, fragmentary specimen. In November, 1939, I received from Mr. H. E. Parks a specimen of *Libocedrus decurrens* bearing apothecia of a *Pesicula*. On examining this material carefully with a dissecting microscope, a few apothecia of a *Dermia* species and conidial fruiting bodies of an associated *Micropera* species were discovered. All the material of the *Dermia* that could be found was on a small piece of bark about 5.5 cm. long and 1.0 cm. in width. An attempt was made to obtain cultures and successful isolations were made from the conidia but the apothecia failed to discharge spores. The cultures from the conidia readily produced conidial fruiting bodies on malt agar.

It is realized that it is rather unsatisfactory to describe a species based on such scanty material. However, Mr. Parks was unable to obtain more and since the characters seem quite distinct it appears desirable to put it on record in the hope that it will be collected again.

Because of the long, sharply pointed conidia, this species might be considered closely related to the group of species described above. The small size of the apothecia, not exceeding 0.5 mm. in the ma-

terial examined, will readily distinguish it from most of the other species with similar conidia, i.e. *D. Cerasi*, *D. balsamea*, and *D. molliuscula*, in all of which the apothecia usually exceed 1 mm. in diameter. The apothecia are closer in size to those of *D. Peckiana* which also has long, pointed conidia, but the apothecia of *D. Libocedri* appear to be mostly single and not clustered on a thick, basal stroma as in *D. Peckiana*. The host is also distinctive.

6. *DERMEA VIBURNI* Groves, Mycologia 32: 745. 1940. (FIGS. 24, 38, 49.)

St. conid.<sup>1</sup>

*Sphaerpenema hystricinum* Ellis, Bull. Torrey Club 6: 106. 1876.

*Sphaerographium hystricinum* Sacc. Syll. Fung. 3: 597. 1884.

*Chondropodium hystricinum* Höhnelt, Fragm. Myk. 958. 1916.

*Sphaerographium hystricinum* var. *Viburni* Dearn. & House, Bull. N. Y. State Mus. 197: 35. 1917.

Apothecia erumpent, separate or in small clusters of 2-6, sessile, slightly narrowed below, circular or slightly undulate, 0.3-0.6(1.0) mm. in diameter and 0.2-0.5 mm. in height, dark brown to black, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium black, at first concave, becoming plane to convex, margin at first raised, later almost disappearing; hypothecium composed of closely interwoven, hyaline to pale brownish, thick-walled hyphae about 5-8  $\mu$  in diameter, in the upper part more or less vertically parallel, curving obliquely toward the outside where the walls are darker colored; subhymenium a narrow brownish zone; asci cylindric-clavate, short-stalked, eight spored, (50)60-75  $\times$  8-12.5  $\mu$ ; ascospores ellipsoid-fusiform, hyaline, becoming slightly yellowish, straight or slightly curved, one or two celled, (10)14-18(20)  $\times$  3.5-5.5  $\mu$ ; paraphyses hyaline, filiform, septate, much branched, 1.5-2.0  $\mu$  in diameter, the tips slightly swollen up to 3  $\mu$  and glued together forming a yellowish epithecium.

Conidial fruiting bodies erumpent, thickly scattered or more or less in rows, single or with two or three arising from the same basal stroma, cylindric-subulate, dark brown to black, often with a reddish tinge—especially when moist—base about 0.3-0.5 mm. in diameter and the beaks about 1 mm. long, hard, leathery to horny, becoming more fleshy when moist; tissue of the basal stroma composed of closely interwoven, ascending, hyaline, thick-walled hyphae about 5-8  $\mu$  in diameter, becoming darker colored and thicker walled at the outside, tissue of the beak similar in structure, the

FIGS. 35-41. Species of *Dermea*.

basal stroma containing a single ovoid to elongated cavity about  $150\text{--}250\ \mu$  in diameter; conidiophores cylindric, septate, occasionally branched, tapering to a slender point,  $15\text{--}30 \times 2.0\text{--}2.5\ \mu$ , lining the cavity and the beak; conidia elongate-fusiform to subfiliform, hyaline, sickle-shaped or sigmoid to almost straight, usually with one end more attenuated than the other, one to four celled,  $(25)30\text{--}45 \times 2.5\text{--}4.0\ \mu$ . No microconidia have been observed in nature.

Host: *Viburnum* spp., *V. Lentago* L., *V. cassinoides* L., *V. nudum* L.

EXSICCATI: Ell. N. Am. Fung. 337 (*Sphaerographium hystricinum*); Rel. Farl. 198a, 198b (*S. hystricinum*).

SPECIMENS EXAMINED: CANADA: Quebec: MacDonald College, DAOM 7649;—Duchesnay, DAOM 5308, JWG 600;—Ontario: Hatchley, T 7937 Type, JWG 433, F;—Timagami Forest Reserve, T 4460; T 4461; T 6976, JWG 230; T 8432; JWG 268;—Wilcox Lake, T 4558, JWG 83;—Parry Sound, T 7171; T 7266, JWG 275;—Petawawa Forest Exp. Stn., DAOM 7322; DAOM 7266, JWG 767.

UNITED STATES: Vermont: Ripton, F;—Massachusetts: Canton, F;—New York: Seventh Lake, Inlet, T.

This species was described by Groves (1940), and the conidial stage discussed. Its genetic connection with the *Dermea* was established. In this species the conidial fruiting bodies are much more conspicuous than the apothecia. The fungus occurs commonly on species of *Viburnum* but usually only the conidial stage is encountered. The apothecia have seldom been collected and when found were usually few and inconspicuous.

It has been placed among the species with long conidia but it differs from the others of this group in having conidia with one end much more attenuated than the other. The apothecia are small, not much larger than those of *D. Libocedri*, but the asci and ascospores are smaller than in this species and the conidial stage is quite different.

7. *DERMEA PADI* (Alb. & Schw.) Fr. Summi. Veg. Scand. p. 362. 1849. (FIGS. 3, 4, 29, 44.)

*Peziza Cerasi*  $\beta$  *Padi* Alb. & Schw. Consp. Fung. Nisk. p. 345. 1805.

*Cenangium Cerasi*  $\beta$  *Padi* Fries, Syst. Myc. 2: 180. 1822.

*Tympanis Padi* Qué. Enchir. Fung. p. 330. 1886.

St. conid.

*Sphaeria fallax* Wahl. Fl. Lapponica p. 522. 1812.

*Cenangium fallax* Fries, Vet. Akad. Handl. p. 361. 1818.

*Sphaeria padina* Pers. in Moug. Stirp. Crypt. no. 667. 1820.

*Micropera padina* Sacc. Mich. 2: 104. 1880.

*Sphacronema brunneo-viride* Auersw. in Sacc., Syll. Fung. 3: 186. 1884.

*Cryptosporium brunneo-viride* Jacz. Nouv. Mém. Soc. Imp. Natur. Moscou 15: 95. 1898.

Apothecia erumpent, gregarious, separate or cespitose in groups of 2-6, sessile, narrowed below, circular or undulate, 0.5-1.0 (1.5) mm. in diameter and about 0.3-1.0 mm. in height, dark reddish-brown to black, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium at first concave, then plane to convex, roughened, black or dark brown, margin at first thick, raised, brownish, furfuraceous, then glabrous and disappearing; tissue of the basal stroma compact, pseudoparenchymatous, composed of hyaline cells 5-10  $\mu$  in diameter, isodiametric to slightly elongated, the walls thickened and gelatinized, arranged in more or less vertically parallel rows, curving toward the outside where the walls are thicker and darker; subhymenium a narrow zone of slender interwoven hyphae; asci cylindric-clavate, tapering to a short stalk, eight spored, (65)85-100(110)  $\times$  10-13(15)  $\mu$ ; ascospores ellipsoid-fusiform, hyaline becoming yellowish, straight or slightly curved, one to two or occasionally four celled, irregularly biseriate, (12)15-20  $\times$  (4)5-7  $\mu$ ; paraphyses hyaline, filiform, septate, simple or branched, 1.5-2.0  $\mu$  in diameter, the tips swollen up to 3  $\mu$  and glued together forming a yellowish epithecium.

Conidial fruiting bodies erumpent, scattered, mostly separate, occasionally two or three in a cluster, cylindric to conic, 0.5-1.3 mm. in height, 0.2-0.5 mm. in diameter, opening circularly at the tip, dark reddish-brown to black, glabrous, hard, leathery to horny in consistency, more fleshy-leathery when moist, containing an elongate-ovoid cavity; tissue of the basal stroma compact, composed of almost isodiametric cells 5-10  $\mu$  in diameter, with thickened, gelatinized walls, in the central part the cells becoming more elongated and the tissue composed of ascending, parallel hyphae, tissue surrounding the cavity composed of three zones, an outer pseudoparenchymatous zone composed of isodiametric, dark walled cells, a middle zone of parallel hyphae about 3-5  $\mu$  in diameter, and an inner zone of small isodiametric cells about 3  $\mu$  in diameter from which the conidiophores arise; conidiophores cylindric, tapering to a slender point, sometimes swollen below the point of attachment

of the spore, septate, simple or branched,  $25-50 \times 2-3 \mu$ ; conidia elongate-fusiform to subfiliform, pointed at the ends, one end usually slightly more pointed than the other, sickle-shaped to almost straight, one or two celled, hyaline,  $(18)20-28(35) \times 2.5-4.0 \mu$ ; microconidia hyaline, bacilliform, straight or slightly curved, one celled,  $4-6 \times 1.5 \mu$ .

HOST: *Prunus* spp. *P. domestica* L., *P. Padus* L., *P. spinosa* L., *P. virginiana* L.

EXSICCATI: All. & Schn. Fung. Bav. 549 (*D. Prunastri*); Roum. Fung. Gall. Exs. 1459 (*Cenangium Prunastri*), 89 (*Sphaeria padina*); Syd. Myc. Germ. 1379 (*Micropera padina*); Lib. Pl. Crypt. Ard. 131.

SPECIMENS EXAMINED: UNITED STATES: New York: Labrador Lake, JWG 460, F, White 2380;—McLean, JWG 471, F, White 2397.

EUROPE: Austria: ex Herb. Barbey-Boissier 1112, T, F.

This species was discussed above under *D. Cerasi*, which it closely resembles. The most striking difference is in the size of the conidia. The apothecia are generally a little smaller, less cespitose, and a little more reddish-brown in color than those of *D. Cerasi* but it is very difficult to separate them in the apothecial stage alone.

I have not collected this species and only one specimen from W. L. White (JWG 460) has been studied in the fresh condition. In it the apothecia failed to discharge spores, but cultures were obtained from the conidia. The cultures resembled those of *D. Cerasi*, but the difference in size of the conidia remained constant in culture.

8. *DERMEA BICOLOR* (Ellis) Groves, Mycologia 35: 460. 1943.  
(FIGS. 19, 20, 33, 45.)

*Tympanis bicolor* Ellis, Amer. Nat. 17: 193. 1883.

*Cenangium bicolor* Sacc. Syll. Fung. 8: 557. 1889.

*Cenangium dichroum* Sacc. Syll. Fung. 8: 1143. 1889.

*Patinella Brenckleana* Sacc. Mycologia 12: 203. 1920.

*Dermea Brenckleana* Seaver, Mycologia 25: 142. 1933.

Apothecia erumpent, gregarious, mostly separate, sometimes in more or less elongated clusters, circular or undulate, sessile, narrowed below, 0.5–1.5 mm. in diameter, 0.5–1.0 mm. in height, at first slightly furfuraceous, yellowish or greenish when moist, finally dark brown to black and glabrous, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium concave to plane or slightly convex, greenish when young and

moist, drying dark brown to black, slightly roughened, at first with a thick, raised, furfuraceous, yellowish margin which may disappear later; tissue of the basal stroma pseudoparenchymatous, composed of hyaline to yellowish, irregular cells about  $5\text{--}12\ \mu$  in diameter, arranged in more or less vertically to obliquely parallel rows above, thicker walled and darker toward the outside forming a firm excipulum, in the central part becoming more elongated and interwoven; subhymenium a zone of interwoven, ascending, hyaline hyphae about  $2\text{--}4\ \mu$  in diameter; asci cylindric-clavate, tapering below to a short stalk, eight spored,  $(56)60\text{--}70(87) \times 8\text{--}10\ \mu$ ; ascospores ellipsoid-fusiform, straight or slightly curved, one or two celled, hyaline becoming yellowish-brown, irregularly biseriate to uniseriate,  $(11)12\text{--}15(16) \times 3\text{--}4(4.5)\ \mu$ ; paraphyses hyaline, filiform, septate, simple or branched,  $1.5\text{--}2.0\ \mu$  in diameter, the tips scarcely swollen but more or less glued together forming an epithecium.

Conidial fruiting bodies splitting the bark, more or less immersed to slightly erumpent, gregarious, variable in shape, circular to elongated or angular,  $0.2\text{--}0.8\ \text{mm.}$  in diameter,  $0.2\text{--}0.4\ \text{mm.}$  in height, yellowish, furfuraceous, more or less wrinkled, soft, waxy, in consistency, becoming more fleshy when moist, containing one to several more or less lobed cavities which open irregularly and sometimes widely, exposing the greenish to yellowish spore masses; tissue compact, pseudoparenchymatous, composed of hyaline, almost isodiametric to irregular cells about  $4\text{--}7\ \mu$  in diameter, sometimes more elongated and interwoven above; conidiophores lining the cavity, hyaline, cylindric, septate, not observed branching, tapering to a pointed tip,  $15\text{--}30 \times 1.5\text{--}2.5\ \mu$ ; conidia hyaline, fusiform, sickle-shaped or almost straight, pointed at the ends, one celled or occasionally two celled,  $(12)15\text{--}20(25) \times 2.5\text{--}4.0\ \mu$ ; no microconidia observed in nature.

Host: *Amelanchier* spp.

SPECIMENS EXAMINED: CANADA: Ontario: Timagami Forest Reserve, T 17324, JWG 412;—Petawawa Forest Exp. Stn., DAOM 7338, JWG 715; DAOM 7512, JWG 720; DAOM 7534, JWG 725; DAOM 7935, JWG 768.

UNITED STATES: Iowa: Decorah, Durand Herbarium 7440, Type of *Tympanis bicolor*;—Whitestone Gully, F. Brenckle 1196, Type of *Patinella Brenckleana*.

This species was recently discussed by Groves (1943). The genetic connection of the conidial stage was established and the evidence for the identity of *Dermea Brenckleana* and *Tympanis bicolor* was presented there. Macroscopically both perfect and im-

perfect stages are similar to those of *D. Cerasi* though somewhat smaller, but microscopically they are both much closer to *D. Ariae*.

9. *DERMEA ARIAE* (Pers. ex Fr.) Tul. ex Karst. Myc. Fenn. 1: 224. 1871. (FIGS. 22, 23, 34, 53.)

*Peziza Ariae* Pers. Myc. Eur. 1: 325. 1822.

*Tympanis Ariae* Fries, Syst. Myc. 2: 175. 1822.

*Cenangium Ariae* Tul. Ann. Sc. Nat. sér III, 20: 136. 1853.

*Tympanis inconstans* Fries, Summa Veg. Scand. p. 400. 1849.

*Cenangium inconstans* Fuckel, Symb. Myc. p. 268. 1870.

*Cenangium subnitidum* Cooke & Phill. Grevillea 3: 186. 1875.

*Phaeangella subnitida* Masee, Brit. Fung. Fl. 4: 137. 1895.

St. conid.

*Sphaeria Cotoneastri* Fries, in Kunze Myk. Heft. 42: 46. 1823.

*Micropera Cotoncastri* Saccardo, Syll. Fung. 3: 605. 1884.

*Sphaeria conica* Alb. & Schw. Consp. Fung. p. 51. 1805.

*Sphaeria Cotoneastri*  $\beta$  *Sorbi* Fries, Syst. Myc. 2: 494. 1823.

*Micropera Sorbi* Sacc. Michelia 2: 104. 1880.

*Sphaerocnema pallidum* Peck, N. Y. St. Mus. Ann. Rep. 25: 85. 1873.

*Phoma pallida* Jacz. Nouv. Mém. Soc. Nat. Moscou 15: 341. 1898.

? *Septoria inaequalis* Sacc. & Roum. Rev. Myc. 6: 35. 1884.

? *Rhabdospora inaequalis* Sacc. Syll. Fung. 3: 580. 1884.

Apothecia erumpent, gregarious, separate or in small clusters of two to four, circular to undulate, sessile, narrowed below, 0.4–0.8 (1.0) mm. in diameter, 0.2–0.4 mm. in height, dark reddish-brown to black, slightly furfuraceous to glabrous, hard, leathery to horny in consistency, more fleshy-leathery when moist; hymenium concave to plane, black, with a thick, raised, brownish margin; tissue of the hypothecium compact, pseudoparenchymatous, composed of irregular, thick-walled cells, 3–8  $\mu$  in diameter, arranged in more or less vertically parallel rows, curving obliquely toward the outside where the walls are thicker and darker; subhymenium a narrow, indefinite zone of slender, interwoven hyphae; asci cylindrical-clavate, narrowed into a short stalk, eight spored, (60)70–90(100)  $\times$  8–10  $\mu$ ; ascospores ellipsoid-fusiform, hyaline to pale yellowish, one to four celled, straight or slightly curved, irregularly biseriate above to uniseriate below, (10)12–18(22)  $\times$  3–5  $\mu$ ; paraphyses hyaline, filiform, septate, simple or branched, 1.5–2.5  $\mu$  in diameter,



the tips swollen up to  $5\ \mu$  and glued together forming a yellowish epithecium.

Conidial fruiting bodies erumpent, gregarious, usually separate, sometimes two or three together, bluntly conical, about  $250\text{--}350\ \mu$  in diameter at the base,  $250\text{--}500\ \mu$  in height, reddish-brown to olivaceous or black, slightly furfuraceous to glabrous, hard, horny in consistency, becoming softer and more fleshy when moist, containing a single, ovoid or slightly chambered cavity; tissue pseudoparenchymatous in the basal stroma, composed of irregular, hyaline cells about  $3\text{--}6\ \mu$  in diameter, becoming prosenchymatous above, composed of ascending, parallel to more or less interwoven hyphae  $2\text{--}3\ \mu$  in diameter, brownish at the outside; conidiophores hyaline, cylindric, simple or branched, continuous or septate, pointed at the tip,  $20\text{--}40 \times 1.5\text{--}2.0\ \mu$ ; conidia hyaline to pale yellowish-green, elongate-fusiform, sickle-shaped or occasionally sigmoid to almost straight, ends pointed, one or two celled,  $(12)15\text{--}20(25) \times 2.0\text{--}4.0\ \mu$ ; microconidia not observed in nature.

Host: *Sorbus americana* Marsh., *S. Aucuparia* L., *Sorbus* spp.

EXSICCATI: Moug. & Nestl. Stirp. Crypt. Vog. 888 (*Peziza Arieae*); Fckl. Fung. Rhen. 1761 (*Tympanis inconstans*); Rehm Ascom. 1057; Phill. Elv. Brit. 94 (*Cenangium subnitidum*); Kl. Herb. viv. myc. 344 (*Tympanis alnea*); Krieg. Fung. Sax. 1516; Roum. Fung. Sel. Gall. 537 (*Peziza Arieae*), 1722 (*Micropera Sorbi*); Syd. Myc. Germ. 1992 (*Micropera Cotoncastri*); Fung. Columb. 571 (*Sphaconema pallidum*).

SPECIMENS EXAMINED: CANADA: Nova Scotia: Truro, JWG 641 ex LEW 402.—Quebec: Duchesnay, DAOM 5301, JWG 609; JWG 626 ex USDA, C. L. Shear 4161.—Ontario: Timagami Forest Reserve, T 4494; T 4495, JWG 68; T 4496, JWG 69, F; T 7283, JWG 180; T 7918, JWG 332, DAOM 2529, F; T 7921, JWG 406; T 7922; JWG 235; JWG 296; JWG 628 ex LOO 18873.

EUROPE: Sweden: Uppsala, JWG 577.—Austria: Neuchatel, T ex Herb. Barbey-Boissier 1120;—Nassau, T ex Herb. Barbey-Boissier 1121, F.

This species was originally described by Persoon (1822) as *Peziza Arieae* and was recognized by Fries (1822) as *Tympanis Arieae*. The combination *Dermea Arieae* usually has been ascribed to Tulasne, but was apparently actually first used by Karsten (1871) who cited Tulasne (1865) as the authority. However, while Tulasne did give an account of both perfect and imperfect stages in this work, and made it perfectly clear that he considered the fungus to belong in *Dermea*, he did not actually make the combination but referred to it as *Cenangium Arieae*.

Neither Persoon nor Fries cited any specimens, but both

Tulasne and Karsten cited Moug. & Nestl. Stirp. Crypt. Vog. 888. The specimen in the Farlow Herbarium under this number is identical with my collections.

The fungus was apparently re-named *Tympanis inconstans* by Fries (1849) and this name was taken up by Fuckel (1870) and transferred to *Cenangium*. Fuckel cited Scler. Suec. 106 and Fung. Rhen. 1761. Rehm (1889) stated that the fungus was *D. Ariae*, and although I have not seen the specimen in Scler. Suec. an examination of the specimen of Fung. Rhen. 1761 in the Farlow Herbarium has confirmed Rehm's opinion.

Groves (1940) has shown that *Cenangium subnitidum* Cke. & Phill. was based on a misdetermination of the host and is also a synonym of *D. Ariae*.

The conidial stage has received a number of names, many of which it has not been possible to verify with certainty and which must remain open to question. Von Höhnelt (1916) compiled a list of synonyms of the conidial stage. No specimens of *Sphaeria conica* Alb. & Schw. have been examined but the original description stated that the fungus occurred on both *Prunus* and *Sorbus*, and since *D. Ariae* is not known to occur on *Prunus* it is doubtful whether *Sphaeria conica* is its conidial stage. A specimen labelled *Micropera Cotoncastri* Fr. in Syd. Myc. Germ. 1992 is the conidial stage of *D. Ariae* as is also a specimen in Fung. Columb. 571 labelled *Sphaeronema pallidum* Peck.

A specimen in Roumeguère Fung. Sel. Gall. Exs. 1722 labelled *Micropera Sorbi* (Lib.) Sacc. is also the conidial stage of *D. Ariae* but the citation is incorrect. It is stated on the label that the fungus is different from *Micropera Sorbi* Thüm., but von Thümen's name is based on Libert's species which was originally described as *Dothichiza Sorbi*. This fungus is not at all related to *Dermea* and according to von Höhnelt (1916) is probably the conidial stage of a *Dothiora*. Saccardo (1880) made the combination *Micropera Sorbi* based not on *Dothichiza Sorbi* Lib. but on *Sphaeria Cotoncastri*  $\beta$  *Sorbi* Fries which evidently was the conidial stage of *D. Ariae*. Thus no such combination as *M. Sorbi* (Lib.) Sacc. ever existed.

*Rhabdospora inaequalis* (Sacc. & Roum.) Sacc. was also listed as a synonym by von Höhnelt (1916) but examination of the speci-

men in Roum. Fung. Sel. Gall. Exs. 3273 in the herbarium of the Division of Botany and Plant Pathology, Ottawa, labelled *R. inaequalis*, yielded only a few brown, ellipsoid, two celled spores with no trace of the conidial stage of *D. Arieae*. However, the original description might apply to the conidial stage of *D. Arieae* and von Höhnelt claimed to have found the fungus in the Roume-guère specimen which he examined; hence it may be that it is another synonym, and it may have just happened that the fungus was not present in the very meagre specimen in the Ottawa packet.

In nature the conidial fruiting bodies are more common and more conspicuous than the apothecia. The asci and ascospores are very similar to those of *D. bicolor* but the apothecia are generally smaller and more brownish in color. The conidia are also very similar in both species but in *D. Arieae* the fruiting bodies are pycnidium-like, usually containing a single cavity, whereas in *D. bicolor* they resemble *Micropera Drupaccarum* in form. The two species are easily distinguished in culture by the color. Cultures of *D. Arieae* are usually rather bright colored whereas those of *D. bicolor* are whitish.

10. *DERMEA HAMAMELIDIS* (Peck) Groves, *Mycologia* 32: 743. 1940. (FIGS. 17, 25, 41, 46.)

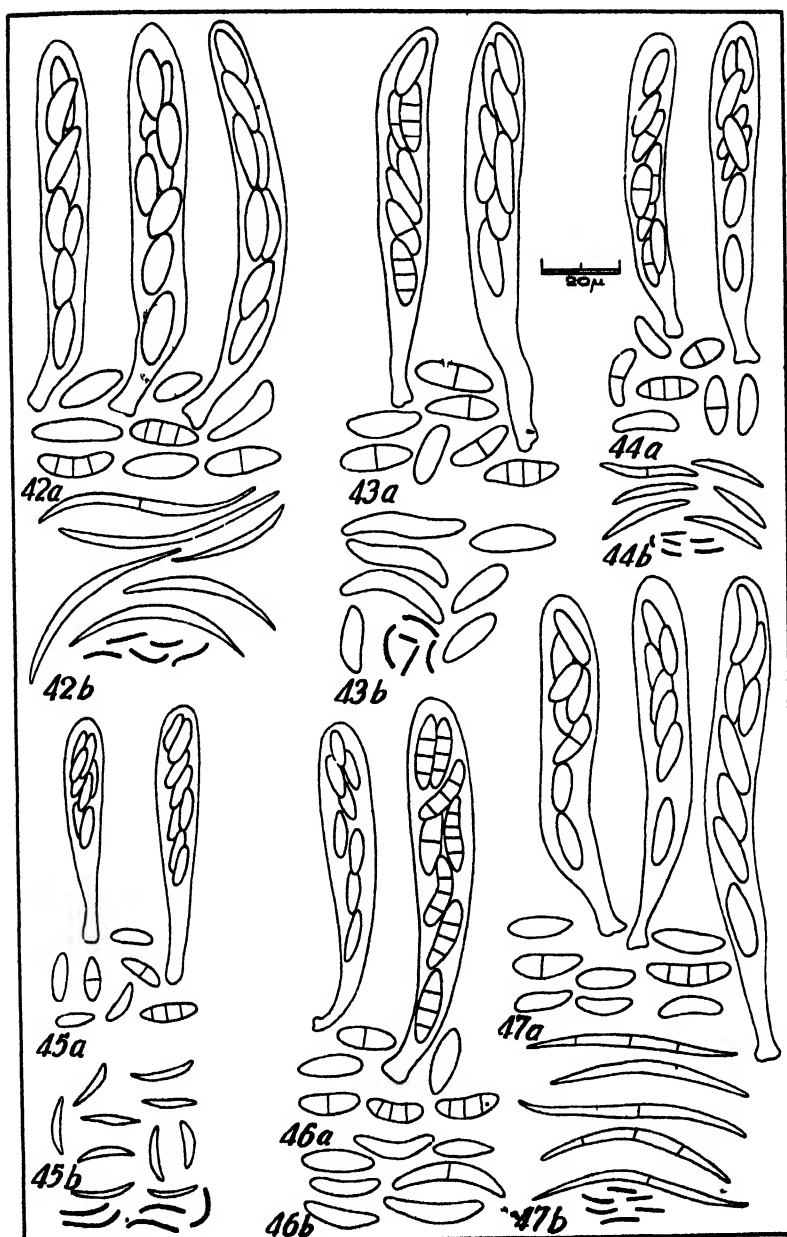
*Patellaria Hamamelidis* Peck, Ann. Rep. N. Y. St. Mus. 33: 32. 1883.

*Lecanidion Hamamelidis* Sacc. Syll. Fung. 8: 800. 1889.

*Dermatella Hamamelidis* Ellis & Ev. Proc. Philad. Acad. Sci. 45: 149. 1893.

*Dermatella Hamamelidis* Durand, Bull. Torrey Club 29: 464. 1902.

Apothecia erumpent, scattered or more or less in rows, separate or in small clusters, circular or somewhat undulate, sessile, narrowed below, 0.3–0.8 mm. in diameter, 0.2–0.4 mm. in height, dark reddish-brown to black, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist, hymenium concave to plane or finally convex, slightly roughened, margin at first raised, later almost disappearing; tissue of the hypothecium compact, pseudoparenchymatous, composed of more or less elongated to almost isodiametric cells 5–12  $\mu$  in diameter, fairly thick walled, dark brown to almost hyaline, arranged in more or less vertically paral-

FIGS. 42-47. Species of *Dermea*.

lel rows, curving obliquely toward the outside where the cells are smaller, darker, and thicker walled; subhymenium a narrow zone of filamentous, interwoven hyphae; asci cylindric-clavate, short-stalked, eight spored,  $(70)80-100(120) \times (10)12-15 \mu$ ; ascospores ellipsoid-fusiform, hyaline to yellowish, straight or slightly curved, irregularly biseriate, one to four celled,  $(13)15-20(22) \times 5.0-7.5 \mu$ ; paraphyses hyaline, filiform, septate, simple or branched,  $1.5-2.0 \mu$  in diameter, the tips slightly swollen and glued together forming a yellowish epithecium.

Conidial fruiting bodies minute, about  $150-200 \mu$  in diameter, developing beneath the outer layers of bark and splitting them, appearing as small, thickly scattered, blister-like elevations in the bark with gray spore-masses emerging through them when moist; in section appearing as an acervulus-like structure with a thin basal layer about  $5-8 \mu$  in thickness, composed of hyaline, indistinct, slender, interwoven hyphae which curve upwards to form the hyaline, cylindric, simple conidiophores,  $10-25 \times 2.0 \mu$ , tapering to a slender tip; conidia elongate-fusiform to subfiliform, hyaline, one or two celled, straight or curved, sometimes one end narrower and more curved than the other,  $(15)18-25(32) \times 4.5-6.0 \mu$ . No microconidia have been observed.

HOST: *Hamamelis virginiana* L.

EXSICCATI: Ell. N. Amer. Fung. 2634; Fung. Columb. 2016.

SPECIMENS EXAMINED: CANADA: Ontario: Toronto, T 4374, JWG 57; T 6565, JWG 271;—Erindale, JWG 162;—Richmond Hill, DAOM 3991, F, T 7928.

UNITED STATES: New Hampshire: Chocorua, Aug. 20, 1907, F; Aug. 31, 1907, F.—New York: Pixley's Falls, T. JWG 285;—Ithaca, F, White 2392, F; Durand 1212;—N. Greenbush, Durand 6096, type of *Patellaria Hamamelidis* Peck;—Lyndonville, Durand 1048.—Pennsylvania: West Chester, F, type of *Dermatella Hamamelidis* E. & E.;—Stoyestown, JWG 661 ex LOO 21692;—Lycoming Co., JWG 667 ex LOO 20139.

*D. Hamamelidis* was originally described by Peck (1883) as a *Patellaria* and was transferred to *Dermatella* by Durand (1902). Ellis and Everhart (1893) described it independently as a new species of *Dermatella*. The types of both *Patellaria Hamamelidis* Peck and *Dermatella Hamamelidis* Ell. & Ev. have been examined and are the same fungus. The species was transferred to *Dermea* by Groves (1940).

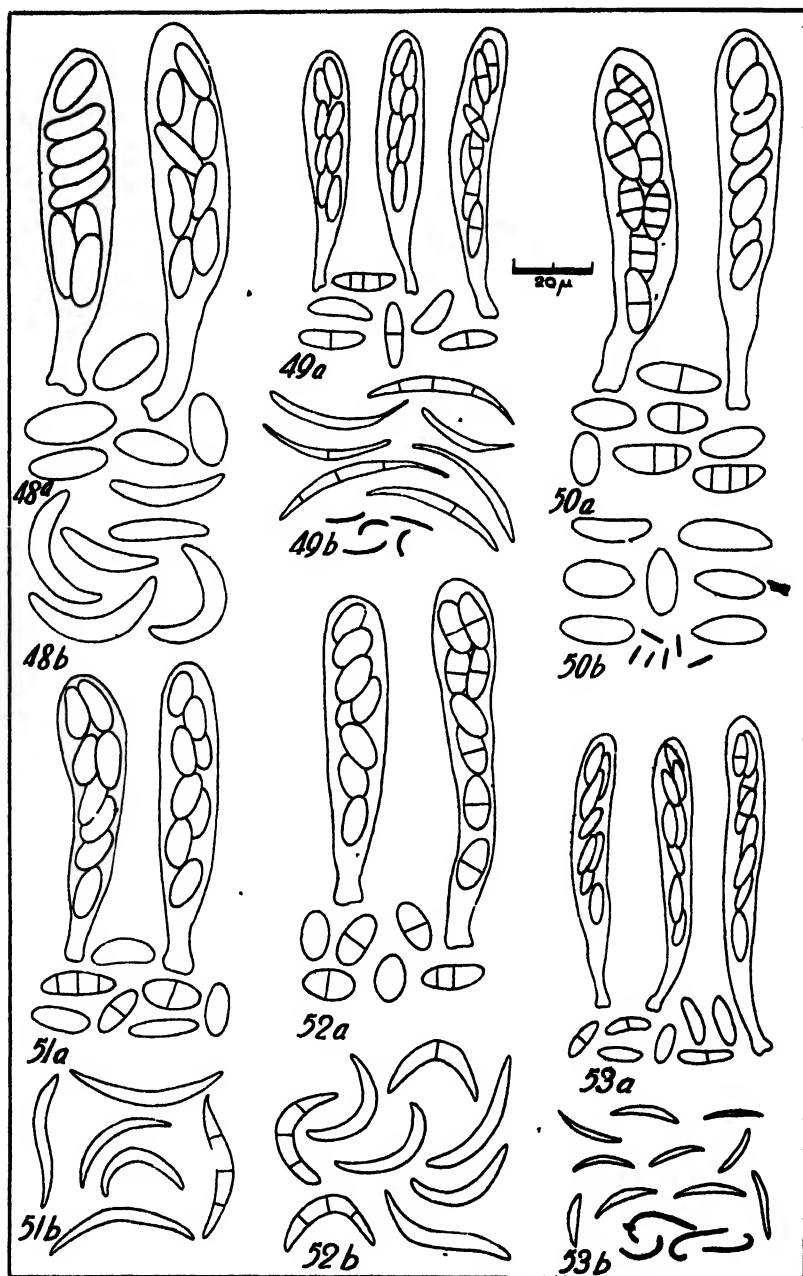
The genus *Dermatella* was erected by Karsten (1871) based on *D. Frangulae* and was separated from *Dermea* by having septate ascospores. *D. Frangulae* has apothecia which become dark col-

ored and resemble apothecia of *Dermea*, especially in the dried condition, but they are softer in consistency, and when moist are lighter colored. The asci are four spored and the ascospores are more broadly ellipsoid than those of *Dermea* species, resembling ascospores of *Pezicula* more closely in shape. Wollenweber (1939) studied this species in culture, and the conidial stage which he found appears to be closer to *Cryptosporiopsis* than to *Micropera*. In general, the affinities of this fungus appear to be nearer *Pezicula* than *Dermea*, and *Dermatella* is, therefore, considered to be a synonym of *Pezicula*. Septation of the ascospores is of no significance in either *Pezicula* or *Dermea* as a generic character.

In *D. Hamamelidis* both apothecia and conidial fruiting bodies are small and inconspicuous. The conidial fruiting bodies are the simplest found in any of the species of *Dermea* studied. This and the five following species form a group that is characterized by the relatively broader conidia with more bluntly rounded ends. *D. Hamamelidis* is easily recognized in culture by the firm, heaped-up, slow-growing colonies, usually with little aerial mycelium.

11. *DERMEA CHIONANTHI* Ell. & Ev. Proc. Acad. Nat. Sci. Philad. 45: 148. 1893. (FIGS. 10, 40, 48.)

Apothecia erumpent, gregarious, more or less in rows, separate or cespitose, sessile, slightly narrowed below, circular or undulate, 0.4–1.0 mm. in diameter, 0.2–0.4 mm. in height, slightly furfureous to glabrous, dark reddish-brown or olivaceous-brown to black, hard, brittle, leathery to horny in consistency, becoming more fleshy when moist; hymenium at first concave, becoming plane to slightly convex, reddish-brown to black, slightly roughened and cracked, margin at first raised and prominent, later almost disappearing; tissue of the basal stroma compact, pseudoparenchymatous, composed of hyaline to brownish, thick-walled, gelatinized cells about 7–18  $\mu$  in diameter, the walls about 2–4  $\mu$  in thickness, arranged in vertically parallel rows, curving toward the outside where the cells are smaller and thicker-walled forming a brownish, pseudoparenchymatous excipulum; subhymenium a narrow, indefinite zone of slender, interwoven hyphae; asci cylindric-clavate, narrowed below, with a rather short stalk, eight spored, 90–110  $\times$  15–20  $\mu$ ; ascospores ellipsoid to ellipsoid-fusiform, hyaline becoming yellowish, one or two (probably four) celled, straight or slightly curved, irregularly biseriate, 18–25  $\times$  (6)7–

FIGS. 48-53. Species of *Dermea*.

9 $\mu$ ; paraphyses hyaline, filiform, septate, simple or occasionally branched, 1.5–2.5  $\mu$  in diameter, the tips slightly swollen up to 3–4  $\mu$  and forming an epithecium.

Conidial fruiting bodies erumpent, separate, black, about 0.2–0.4 mm. in diameter and 0.2 mm. in height, rounded, somewhat irregular to slightly conical, tearing open widely at the top, fleshy-membranous, becoming more fleshy when moist, containing a single cavity the base of which is lined with conidiophores, tissue prosenchymatous below, composed of more or less vertically parallel to slightly interwoven hyphae about 2.5–3.0  $\mu$  in diameter, becoming pseudoparenchymatous above, composed of darker, thick-walled, gelatinized cells about 5–7  $\mu$  in diameter; conidiophores hyaline, cylindric, simple or occasionally branched, continuous or septate, tapering to a fine point at the tip where the spore is borne, often swollen just below the tapering tip, 12–30  $\times$  3–4  $\mu$ ; conidia elongate-fusiform to subfiliform, hyaline, curved, sickle-shaped to almost straight, one or two celled, bluntly pointed at the ends, 25–35  $\times$  5–7  $\mu$ ; no microconidia observed.

Host: *Chionanthus virginica* L.

EXSICCATI: Fung. Columb. 2423.

SPECIMENS EXAMINED: UNITED STATES: Delaware: Wilmington, NYBG, type.—Maryland: Suitland, JWG 748 ex USDA.

This is the only species of *Dermea* included in this paper which I have neither seen in fresh condition nor studied in culture. The type was kindly loaned by Dr. F. J. Seaver and agreed very well with the specimens in Fung. Columb. 2423 and the Maryland collection which was received from Miss E. K. Cash. The conidial stage described above was found in the latter specimen and although the connection has not been proved culturally, the nature of its association with the apothecia and its similarity to conidial stages of closely related species of *Dermea* leave little doubt of its relation to *D. Chionanthi*. The conidial fruiting bodies, although inconspicuous, are much better developed than in *D. Hamamelidis*.

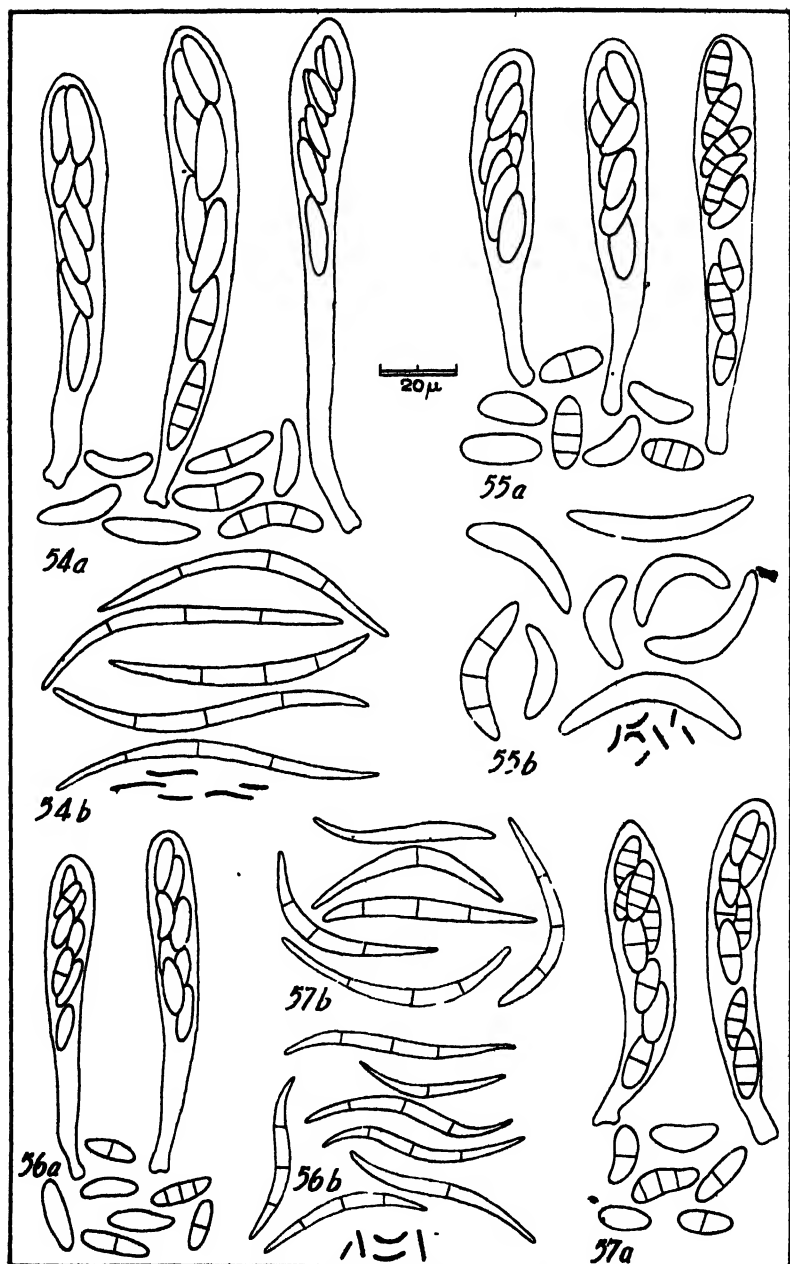
12. *Dermea Tulasnei* nom. nov. (FIGS. 13, 14, 37, 55.)

*Cenangium Fraxini* sensu Tul. Ann. Sc. Nat. III, 20: 140. 1853.

*Cenangella Fraxini* sensu Sacc. Cons. gen. Disc. p. 9. 1884.

*Dermea Fraxini* sensu Rehm, Ber. Bayer. Bot. Ges. 13: 196. 1912.



FIGS. 54-57. Species of *Dermocystis*.

*Dermea Fraxini* sensu v. Höhn. Fragm. z. Myk. No. 914. 1915.  
St. conid.

*Fusicoccum cryptosporioides* Bomm., Rouss., Sacc. Contr. Myc.  
Belg. 4: 80. 1891.

*Micropera cryptosporioides* v. Höhn. Fragm. z. Myk. No. 914.  
1915.

Apothecia erumpent, scattered, separate or in small clusters, circular or slightly undulate, sessile, slightly narrowed below, 0.5–1.0 mm. in diameter, 0.2–0.6 mm. in height, hard, waxy-leathery to horny in consistency, becoming more fleshy when moist; hymenium concave to plane or slightly convex, dark reddish-brown to almost black, at first with a slightly raised, paler margin which later almost disappears; tissue compact, pseudoparenchymatous, composed of thick-walled cells 5–12  $\mu$  in diameter, in the upper part more elongated and somewhat interwoven, the excipulum composed of darker, isodiametric cells in obliquely parallel rows; subhymenium a narrow zone of slender, closely interwoven hyphae; asci cylindric-clavate, tapering into a short stalk, eight spored, (75)85–100(115)  $\times$  14–18(20)  $\mu$ ; ascospores hyaline to pale yellowish-green, ellipsoid-fusiform, straight or slightly curved, one to four celled, irregularly biserial, (13)15–20(22)  $\times$  6–8(10)  $\mu$ ; paraphyses hyaline, filiform, septate, usually branched, 2.0–3.0  $\mu$  in diameter, the tips slightly swollen and glued together forming a yellowish epithecium.

Conidial fruiting bodies erumpent, scattered, rounded to short-conical, 150–500  $\mu$  in diameter, 200–400  $\mu$  in height, sometimes in elongated clusters up to 1 mm. in length, dark reddish brown to black, consistency a little softer than the apothecia, in the upper part containing one or sometimes several, more or less ovoid, simple to slightly chambered cavities which tear open irregularly at the top; tissue pseudoparenchymatous, composed of slightly colored, irregular, thick-walled cells 5–12  $\mu$  in diameter, and arranged in more or less vertically parallel rows, curving toward the outside; conidiophores cylindric, continuous or septate, sometimes slightly constricted at the septa, simple or branched, pointed at the tip, 25–50  $\times$  4–5  $\mu$ ; conidia hyaline to pale yellowish green, elongate-fusiform, scarcely subfiliform, one celled or occasionally septate, strongly curved to almost straight, 25–40(50)  $\times$  (5.5)6–8  $\mu$ .

HOST: *Fraxinus nigra* Marsh., *Fraxinus* spp.

SPECIMENS EXAMINED: CANADA: Quebec: Burnet, DAOM 4556, JWG 545;—Ile Jésus, DAOM 7340.—Ontario: Timagami Forest Reserve, T 8426, JWG 177; T 7927, JWG 305; T 7653, JWG 403, F;—Toronto, T

8431, 8448, JWG 457, F; JWG 468;—Pctawawa For. Exp. Stn., DAOM 5217, JWG 573; JWG 810.

The nomenclature of this and related Discomycetes occurring on *Fraxinus* has been much confused. The earliest name is *Peziza Fraxini* Schw., published in 1822. A fragment of the type of this species in the Durand Herbarium, Cornell University, was seen and it is the fungus now known as *Durandiella Fraxini* (Schw.) Seaver which has the gross appearance of a *Tympanis* but has fili-form ascospores. In the *Systema Mycologicum* (1822) Fries recognized Schweinitz' species under the name of *Tympanis Fraxini*.

Tulasne (1853) described a fungus on *Fraxinus* which he referred to as "*Cenangium Fraxini* Nob. (*Tympanis Fraxini* Fr., S. M. II, 174)." Thus Tulasne evidently thought his fungus was *Tympanis Fraxini* Fr. although from his account it is clear that he had the *Dermca* and not the *Durandiella*. Therefore, Tulasne's combination was based on a misdetermination and according to Article 54 of the International Rules his combination must be regarded as a synonym of *Peziza Fraxini* Schw.

The error was perpetuated by Saccardo (1884) who based his genus *Cenangella* on Tulasne's fungus and called it *Cenangella Fraxini* (Tul.) Sacc.; and also by Rehm (1912) and von Höhnell (1915) who each transferred it to *Dermca* independently. Since all of the names are based on the specific epithet *Fraxini* which is ultimately based on Schweinitz' type, they must all be considered as synonyms of *Durandiella Fraxini*. The *Dermca* is thus left without a name and it is necessary to give it a new name.

It is evident from the descriptions given by Rehm (1889) and Phillips (1893) that a true *Tympanis* species with multispored asci also occurs on *Fraxinus* in Europe and has been referred to *Tympanis Fraxini* also. It would seem that the correct name of this *Tympanis* is *T. columnaris* (Wallr.) v. Höhn.

*Dermatella Fraxini* Ell. & Ev. is based on a different type and the specific name is, consequently, valid. A portion of the type in the Durand Herbarium 7369 was examined but no asci or ascospores were found. The specimen in Ellis N. Amer. Fung. 2633 is apparently a later collection from the same locality as the type and is similar in gross appearance. This fungus is a *Pezicula*.

*D. Tulasnei* appears to be rare and it is difficult to find it in abundance. The apothecia are softer in consistency than most *Dermeae* and approach the genus *Pezicula* in this respect. As noted above it is morphologically close to *D. Chionanthi* in both perfect and imperfect stages.

13. *Dermea pinicola* sp. nov. (FIGS. 15, 51.)

Apotheciis erumpentibus, gregariis, solitariis vel caespitosis, orbicularibus vel undulatis, sessilibus, versus basim attenuatis, 0.3–0.5(0.8) mm. diam., 0.2–0.4 mm. altis, brunneis vel atris, coriaceis vel corneis in sicco, carnosocoriaceis in humido; hymenio concavo vel plano, marginato; hypothecio pseudoparenchymato; ascis cylindraceo-clavatis, breve stipitatis, octosporis, (60)70–90(100) × (12)14–17(20)  $\mu$ ; ascosporis ellipsoideis vel ellipsoideo-fusiformibus, hyalinis, rectis vel laeve curvulis, continuis vel uniseptatis, 13–18(20) × 5–7.5  $\mu$ ; paraphysibus hyalinis, filiformibus, septatis, simplicibus vel ramosis, 1.5–2.0  $\mu$  diam., apice leviter incrassatis, agglutinatis, epithecium formantibus.

Hab. *Pinus Strobus* L.

Apothecia erumpent, gregarious to scattered, separate or in small clusters of two to six, circular or slightly undulate, sessile, narrowed below, 0.3–0.5(0.8) mm. in diameter, 0.2–0.4 mm. in height, dark reddish-brown to black, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist, hymenium concave to plane or slightly convex, slightly roughened, the margin at first raised and somewhat inrolled, later almost disappearing, a little paler than the hymenium; tissue of the hypothecium compact, pseudoparenchymatous, composed of pale brownish, thick-walled, almost isodiametric, angular cells mostly 5–8  $\mu$  in diameter, arranged in more or less vertically parallel rows, curving obliquely to the outside where the walls are thicker, sometimes the cells more elongated in the upper central part; subhymenium indistinct; asci cylindric-clavate, short-stalked, eight spored, (60)70–90(100) × (12)14–17(20)  $\mu$ ; ascospores ellipsoid to ellipsoid-fusiform, hyaline, straight or slightly curved, one or two celled, irregularly biseriate, 13–18(20) × 5.0–7.5  $\mu$ ; paraphyses hyaline, filiform, septate, simple or branched, 1.5–2.0  $\mu$  in diameter, the tips slightly swollen to 3  $\mu$  and glued together forming an epithecium.

Host: *Pinus Strobus* L.

TYPE: West mainland, Lake Timagami, Ont. Aug. 24, 1935. DAOM 14973.

SPECIMENS EXAMINED: CANADA: Ontario: Timagami Forest Reserve, JWG 317; DAOM 14973, JWG 402, T.

UNITED STATES: Vermont: Dummerston, JWG 803.

This species appears to be rare. It has only been collected twice and a third specimen was found on one twig in a collection of a *Tympanis* species on pine received from J. R. Hansbrough (JRH 1510). This is the only species in which no conidial stage has been found in nature, but cultures from ascospores produced a *Micropera* stage.

The conidial fruiting bodies, both on agar and on sterilized twigs of the host, develop as rounded, fleshy stromata, which are glabrous or covered with a short, downy to tomentose mycelium. They are mostly about 0.5 mm. in diameter, sometimes larger, and usually contain a single cavity. The conidiophores are hyaline, cylindric, septate, simple or branched, and measure  $20-45 \times 3-4 \mu$ . The conidia are elongate-fusiform to subfiliform, hyaline, sometimes becoming yellowish, mostly sickle-shaped, or nearly straight to sigmoid, one end more pointed than the other, one to four celled, and measure  $(25)30-40(50) \times 4-6 \mu$ .

Among the various species of fungi reported on pine as species of *Dermea* or related genera, the only one which seems close to this species is *D. microspora* Vel. However, apothecia of the latter are described as 0.2-0.4 mm. in diameter, the asci  $70-80 \times 10 \mu$ , and the ascospores as  $12-15 \mu$  in length with the width not stated. Except for the diameter of the asci, these dimensions agree fairly well with my species. It has not been possible to see any specimens of *D. microspora* and until the two are compared it will be impossible to say with certainty whether or not they are identical. In the meantime it seems preferable to consider the North American fungus as distinct.

#### 14. *Dermea piceina* sp. nov. (FIGS. 11, 12, 32, 52.)

Apotheciis erumpentibus, dispersis, solitariis vel caespitosis, orbicularibus vel undulatis, sessilibus, versus basim attenuatis, 0.5-1.5 mm. diam., 0.5-1.0 mm. altis, brunneis vel atris, coriaceis vel corneis in sicco, carnosio-coriaceis in humido; hymenio concavo dein plano vel convexo, olivaceo-brunneo vel rubro-brunneo vel atro, marginato; hypothecio plectenchymato; ascis cylindraceo-clavatis, octosporis, breve stipitatis,  $75-105 \times (12)14-16(17) \mu$ ; ascosporis ellipsoideis vel ellipsoideo-ovoideis, primo hyalinis, dein fuscis, continuis vel triseptatis, rectis vel leviter curvulis,  $(11)12-14(18) \times (5)6-8 \mu$ ; paraphysibus hyalinis, filiformibus, septatis, simplicibus vel ramosis,  $1.5-2.0 \mu$  diam., apice leviter incrassatis, epithecium formantibus.

Hab. *Picea glauca* Voss.

Apothecia erumpent, scattered, separate or cespitose in small clusters of about two to six, circular or slightly undulate, sessile, narrowed below to substipitate, 0.5–1.5 mm. in diameter, 0.5–1.0 mm. in height, dark reddish-brown to black, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium at first concave, soon plane to convex, slightly furfuraceous, dark olive-brown to dark reddish-brown to almost black, at first with a darker, slightly raised margin which later may disappear; tissue compact, plectenchymatous, composed of interwoven, ascending hyphae about  $3\text{--}5\ \mu$  in diameter, the walls brown or purple-brown, somewhat thickened and gelatinized, almost vertically parallel in the central part, curving obliquely toward the outside where the walls are thicker and darker and the hyphae closely septate, forming a pseudoparenchymatous zone of several cells thickness, the cells about  $3\text{--}6\ \mu$  in diameter; subhymenium a narrow zone of hyaline, interwoven hyphae; asci cylindric-clavate, short stalked, eight spored,  $75\text{--}105 \times (12)14\text{--}16(17)\ \mu$ ; ascospores ellipsoid to ellipsoid-ovoid, hyaline becoming brownish, one or two (to four) celled, irregularly biseriate to crowded,  $(11)12\text{--}14(18) \times (5)6\text{--}8\ \mu$ ; paraphyses hyaline, filiform, septate, simple or branched,  $1.5\text{--}2.0\ \mu$  in diameter, the tips slightly swollen up to  $3\ \mu$ , forming a slight epithecium.

Conidial fruiting bodies erumpent, scattered, mostly single, minute, black or greenish-black, glabrous, 0.1–0.3 mm. in diameter, almost globose, opening at the tip and the spores emerging in a whitish to pale greenish mass or cirrhous, tissue plectenchymatous, composed of interwoven, ascending hyphae curving outward and upward around the ovoid cavity in the upper part, with a pseudoparenchymatous zone at the outside composed of cells  $3\text{--}7\ \mu$  in diameter; conidiophores lining the cavity, hyaline, cylindric, pointed at the tip, septate, simple or branched,  $15\text{--}30 \times 2\text{--}3\ \mu$ ; conidia elongate-fusiform, hyaline, strongly curved to nearly straight or occasionally sigmoid, pointed at the ends, one end usually more pointed than the other, one to four celled,  $22\text{--}40 \times 3\text{--}5\ \mu$ ; microconidia hyaline, filiform, one celled, strongly curved, ends rounded,  $9\text{--}15 \times 1.0\text{--}1.5\ \mu$ .

HOST: *Picea glauca* Voss.

TYPE: Petawawa Forest Experiment Station, Ontario, Sept. 2, 1943. DAOM 14974.

SPECIMENS EXAMINED: CANADA: Ontario: Petawawa Forest Experiment Station, DAOM 14974, JWG 793; JWG 770.

This species was first collected in September, 1942 but very little material was found. The following year a special search was

made for it in the same locality and a good collection was obtained. It is close to *D. pinicola* but the ascospores of the latter tend to be more fusoid whereas those of *D. piceina* are more ellipsoid and rounded at the ends, and a little broader in proportion to their length. The conidia are very similar in the two species but slightly broader in *D. piceina*, which has slightly larger and more scattered apothecia. Both species appear to be rare.

None of the fungi described on *Picea* as species of *Dermea* or related genera agrees with this species as far as could be ascertained. The description of *Dermea Pini* Otth, which has been reported on *Picea excelsa*, is too meagre to enable the fungus to be recognized and it has not been possible to see any specimens. It is described as having a *Micropera*-like conidial stage but the conidia as described are longer and narrower than those of *D. piceina*.

*D. piceina* was found on the mature bark of trunks of fallen trees and is quite inconspicuous. The conidial fruiting bodies are very small and can be most easily detected by leaving the material in a moist chamber over night and searching for the fresh spore horns. The cultures somewhat resemble those of *D. molliuscula* and *D. Prunastri* but the conidia are very different from both of these species.

15. *DERMEA PRUNASTRI* (Pers. ex Fr.) Fr. Summ. Veg. Scand. p. 362. 1849. (FIGS. 5, 6, 28, 43.)

*Peziza Prunastri* Pers. Tent. disp. meth. p. 35. 1797.

*Cenangium Prunastri* Fr. Syst. Myc. 2: 180. 1822.

*Tympanis Prunastri* Wallr. Flor. Crypt. Germ. 2: 427. 1833.

*Phaeangella Prunastri* Masee, Brit. Fung. Fl. 4: 137. 1895.

*Dermatella Prunastri* Dowson, New Phytol. 12: 207. 1913.

St. conid.

*Ceratostoma spurium* Fr. Obs. Myc. 2: 338. 1818.

*Sphaeronema spurium* Sacc. Syll. Fung. 3: 186. 1884.

*Micropera spuria* v. Höhn. Fragm. z. Myk. No. 950. 1916.

*Sphaeria rigida* DC. Fl. Fr. 6: 132. 1815.

*Cenangium Prunastri*  $\beta$  *rigida* Fr. Syst. Myc. 2: 180. 1822.

? *Cenangium rigidum* Schw. Syn. Fung. p. 238. 1832.

? *Dendrophoma fusispora* v. Höhn. Fragm. z. Myk. No. 21. 1902.

? *Micropera fusispora* v. Höhn. Mitt. Bot. Lab. Techn. Hochsch. in Wien 1: 24. 1924.

Apothecia erumpent, scattered, cespitose, occasionally single, sessile, narrowed below, circular or undulate, 0.5–1.0(1.2) mm. in diameter, 0.2–1.0 mm. in height, dark brown to black, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium concave to plane or slightly convex, black, roughened, margin at first thick, raised, sometimes incurved, brownish, later almost disappearing; tissue of the hypothecium compact, pseudoparenchymatous, composed of more or less elongated to almost isodiametric cells 7–15  $\mu$  in diameter with thickened and gelatinized walls, toward the outside arranged in more or less oblique rows and darker walled; subhymenium a narrow zone of more slender, closely interwoven hyphae; asci cylindric-clavate, short stalked, eight spored, (80)90–115(125)  $\times$  (10)12–14(15)  $\mu$ ; ascospores ellipsoid-fusiform, hyaline, becoming yellowish, one to four celled, straight or slightly curved, irregularly biseriate, (12)15–20(25)  $\times$  5.0–7.5  $\mu$ ; paraphyses hyaline, filiform, septate, simple or branched, 1.5–2.0  $\mu$  in diameter, the tips slightly swollen to 2.5–3.0  $\mu$  and glued together forming a yellowish epithecium.

Conidial fruiting bodies erumpent, cespitose, occasionally single, cylindric to cylindric-conic or subulate, 1–2 mm. in height, 0.2–0.4 mm. in diameter at the base, arising from a more or less circular to transversely elongated basal stroma, black to greenish or olivaceous when moist, glabrous, hard, horny, brittle, becoming more fleshy-leathery when moist, containing a single, ovoid cavity which is frequently in the tip of the beak only but may extend down into the basal stroma, tissue of the basal stroma similar to that of the apothecia, the cells in the beak arranged in more or less vertically parallel rows; conidiophores hyaline, cylindric, tapering to a slender point, septate, simple, 20–35  $\times$  2.5–3.0  $\mu$ ; conidia elongate-fusiform, hyaline to slightly greenish-yellow, one celled, almost straight to slightly sickle-shaped, occasionally sigmoid, ends pointed, (15)20–30(35)  $\times$  (4.0)5.0–7.0  $\mu$ ; microconidia hyaline to yellowish, filiform, straight or slightly curved, one celled, ends rounded, 7–10  $\times$  1.5  $\mu$ .

Host: *Prunus* spp.

EXSICCATI: Fung. Col. 3118 (*D. Cerasi*); Jaap Fung. Sel. Exs. 605.

SPECIMENS EXAMINED: CANADA: Nova Scotia: Colchester Co., JWG 798 ex LEW 1692.—Quebec: St. Alphonse, DAOM 3789; DAOM 3793;—Duchesnay, JWG 597;—Ile Jésus, JWG 733;—Eardley, DAOM 4681, JWG 562, F.—Ontario: Timagami Forest Reserve, T 4382, JWG 8; T 6568,



JWG 227; T 6984, JWG 284; T 6594, F; JWG 174; JWG 225; JWG 242; JWG 333; JWG 425, DAOM 2542, F; DAOM 2527;—Toronto, T 4381, JWG 2; JWG 84;—Petawawa For. Exp. Stn., DAOM 4713.

UNITED STATES: South Carolina: F.—New Hampshire: Mason, JWG 774 *ex* Darker 6854.—New York: Buffalo, F.—Idaho: Bonner Co., JWG 759, DAOM 12059; JWG 760.—Washington: Marysville, F;—Bremerton, DAOM, F *ex* USDA 1402 (*D. Cerasi*).

EUROPE: Germany: Leipzig F, *ex* Herb. Barbey-Boissier 1111.

This species was discussed under *D. Cerasi*. It has not been possible to examine any type material and the identification rests chiefly on the descriptions of the conidial stage. However, this is so characteristic that there seems little doubt of the identity of the fungus. It has been well illustrated by Arnaud (1931, pp. 1330–1334).

Dowson (1913) showed that this species was the cause of a die-back of greengage plums. He referred to it as *Dermatella Prunastri* Pers., but Dowson's paper appears to be the first in which the fungus was called *Dermatella*. The only citation he gave as authority for this name is the following statement: "Rabenhorst, referring to it as *Dermatella Prunastri*, considers the group genus *Dermatca* to be subdivided into three subgenera of which *Dermatella* is the third, the others being *Eudermatca* and *Pezizicula*." Presumably he meant Rehm's account in Rabenhorst's Kryptogamen Flora, but Rehm used *Dermatella* only as a subgenus and the fact that he placed this fungus there as *D. Prunastri* does not indicate that he intended to make a *Dermatella* combination. This is obvious when compared with his treatment of the species placed under the subgenus *Pezicula* to which he also referred under the initial *D.* Evidently, therefore, Dowson himself must be considered as the author of this combination. Certainly, there is no justification for ascribing it to Persoon.

The conidial stage may be found fairly frequently on small, dead twigs of *Prunus* but the apothecia occur less often. They are smaller and usually more cespitose in growth habit than either *D. Cerasi* or *D. Padi* but the asci and ascospores are very similar in all three. The conidial fruiting bodies and the size and shape of the conidia provide the best distinguishing characters. Cultures of *D. Prunastri* can be distinguished easily from the other two by

their yellowish to olive color, firm consistency and relatively slow rate of growth.

16. *DERMEA ACERINA* (Peck) Rehm, Ber. Bayer. Bot. Ges. 13: 197. 1912. (FIGS. 16, 36, 50.)

*Tympanis acerina* Peck, Ann. Rep. N. Y. St. Mus. 31: 48. 1879.  
*Scleroderris acerina* Sacc. Syll. Fung. 8: 599. 1889.

? *Patellaria acericola* Atk. in herb. Mycologia 32: 810. 1940.

? *Lecanidion acericolum* Atk. in herb. Ann. Rep. N. Y. St. Mus. 49: 24. 1896.

St. conid.

*Sphaeronema accrinum* Peck, Ann. Rep. N. Y. St. Mus. 24: 86. 1872.

*Sphaeronema nigripes* Ellis, Bull. Torrey Club 6: 107. 1876.

*Nacmosphaera acerina* von Höhnelt, Fragm. z. Myk. No. 959. 1916.

Apothecia erumpent, scattered, sometimes in rows, separate or in small clusters, circular or undulate, 0.4–1.0 mm. in diameter, 0.2–0.5 mm. in height, sessile, narrowed below, black or dark brownish, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium at first concave, becoming plane or slightly convex, the margin at first thick, raised, later almost disappearing, usually slightly paler than the disc; tissue of the hypothecium compact, pseudoparenchymatous, composed of brownish, almost isodiametric to slightly elongated cells 4–8  $\mu$  in diameter, toward the outside arranged in oblique rows with the walls thick and dark, but in the central part more elongated and interwoven; asci cylindric-clavate, short stalked, eight spored, (70)85–110(125)  $\times$  (10)13–16  $\mu$ ; ascospores oblong-ellipsoid to ellipsoid-fusiform, hyaline becoming yellowish, one to four celled, straight or sometimes slightly curved, irregularly biseriate to uniseriate, 13–20  $\times$  5–8  $\mu$ ; paraphyses hyaline, filiform, septate, simple or branched, 1.5–2.0  $\mu$  in diameter, the tips slightly swollen and glued together forming a yellowish epithecium.

Conidial fruiting bodies erumpent, usually in long rows, separate, sometimes cespitose in small clusters, subulate, basal stroma subglobose to ovoid, 0.2–0.5 mm. in diameter, dark brown to black, hard, leathery to horny in consistency, more fleshy-leathery when moist; the beak slender, tapering, straight or sometimes curved, brittle, up to 1.5 mm. in length and 100–150  $\mu$  in diameter at the

base and tapered to  $50\text{--}75\ \mu$  at the tip, dark brown to black at the base, becoming paler and often somewhat translucent toward the tip; tissue of the basal stroma pseudoparenchymatous, composed of yellowish-brown cells  $5\text{--}8\ \mu$  in diameter, somewhat more elongated around the cavity, the beak composed of hyaline to pale brownish, parallel hyphae about  $1.5\text{--}2.0\ \mu$  in diameter; the cavity ovoid,  $150\text{--}175 \times 225\text{--}250\ \mu$ , filled with numerous, hyaline, branched, hair-like paraphyses about  $1.0\ \mu$  in diameter and embedded in a slimy material; conidiophores hyaline, cylindric, continuous or septate, simple,  $20\text{--}40 \times 2.0\ \mu$ , often swollen to  $3\text{--}4\ \mu$  below, the pointed tip; conidia oblong-ellipsoid, hyaline, straight or sometimes slightly curved, one celled, ends rounded, one end with a truncate apiculus, sometimes one end narrower than the other,  $15\text{--}25 \times 5\text{--}8\ \mu$ ; microconidia hyaline, filiform, one celled, straight or curved,  $6\text{--}10 \times 1.0\text{--}2.0\ \mu$ .

Host: *Acer* spp., *A. rubrum* L., *A. saccharum* Marsh., *A. saccharinum* L.

EXSICCATI: Rel. Farl. 143; Fung. Columb. 2086; 3585; N. Amer. Fung. 947; 3441; Syd. Fung. exot. ex. 429.

SPECIMENS EXAMINED: CANADA: Nova Scotia: Casey's Corners, DAOM 4652, JWG 558.—Quebec: Duchesnay, DAOM 5305, JWG 602; DAOM 5310, JWG 595;—MacDonald College, DAOM 7326;—Kingsmere, JWG 113; Hull, JWG 128.—Ontario: Timagami Forest Reserve, T 3006, JWG 71;—T 3524, JWG 22; T 3531, JWG 49; T 4472; T 6563, JWG 260, F; T 6577, JWG 247; T 6958, JWG 259; T 7281; T 7913; T 7914; T 7915, JWG 396; T 7916; JWG 246; JWG 316; JWG 487;—Toronto, T 6562, JWG 273; T 7398, JWG 134; T 7399, JWG 681; T 7917; JWG 52; JWG 53; JWG 94;—Peel Co., T 6109;—Brant Co., T 8433;—Ottawa, T 4839, JWG 108; JWG 109; DAOM, JWG 130;—Petawawa For. Exp. Stn., DAOM 4695; DAOM 7320, JWG 718.

UNITED STATES: Virginia: Mt. Lake, JWG 506.—Maine: Mt. Katahdin, F, White 3522.—New York: Griffins, Durand Herbarium 3022 (part of type);—MacLean, F, White 2393, JWG 463.—Michigan: Vermilion, DAOM 7593, T.

This species was first described by Peck (1879) as *Tympanis acerina*, evidently on the basis of the gross appearance of the apothecia since it is very different in microscopic characters from members of this genus. The ascospores were described as three-septate and Saccardo (1889) transferred it to *Scleroderris* in order to place it in his system, although it is not at all similar to the urceolate species with narrow-fusoid ascospores usually referred

there. Rehm (1912) finally transferred it to *Dermea* where it seems advisable to leave it at present although it shows certain aberrant characters of which the most noteworthy is the shape of the conidia.

The oblong-ellipsoid conidia are similar in form to conidia of species of the related genus *Pezicula*, and this has led to confusion regarding the specific identity and conidial relations of this fungus and of species of *Pezicula* occurring on *Acer*. Groves (1938, 1941) has established the genetic connection of *D. acerina* and *Naemosphaera acerina* by cultural methods, and has shown that there are three distinct species of *Pezicula* occurring on *Acer*, all of which have conidial stages belonging to the form genus *Cryptosporiopsis*, and which can be distinguished by the gross appearance of the apothecia, the size of the asci and ascospores, and the size of the conidia.

*D. acerina* is frequently found growing closely associated with *Pezicula carnea* (Cke. & Ell.) Rehm but can be readily distinguished from it by the color of the apothecia which are black in *D. acerina* and ochraceous buff in *P. carnea*. The conidial fruiting bodies of *D. acerina* are conspicuous, beaked pycnidia whereas in *P. carnea* they are very inconspicuous, fleshy stromata developing beneath the layers of outer bark.

In a sense, however, *D. acerina* does form a connecting link between *Dermea* and *Pezicula*. This is even more apparent when it is compared with *P. Frangulae*. In both of these species the apothecia are similar in gross appearance when dried and the ascospores and conidia of both species are similar in form. It is, perhaps, questionable whether *P. Frangulae* should not be retained in *Dermea* also. However, when moistened its apothecia become more *Pezicula*-like. I have not studied *P. Frangulae* in culture but Wollenweber (1939) cultured it and considered it to be a *Pezicula* and this interpretation is accepted. It is evident that although the retention of both *Dermea* and *Pezicula* serves a useful purpose since both include a number of species apparently representative of different lines of development, it is difficult to draw a clear-cut separation between them.

## GENERIC HOST INDEX

<i>Abies</i>	<i>Nemopanthus</i>
<i>D. balsamea</i>	<i>D. Peckiana</i>
<i>Acer</i>	<i>Picea</i>
<i>D. acerina</i>	<i>D. piccina</i>
<i>Amelanchier</i>	<i>Pinus</i>
<i>D. bicolor</i>	<i>D. pinicola</i>
<i>Betula</i>	<i>Prunus</i>
<i>D. molliuscula</i>	<i>D. Cerasi</i>
<i>Chionanthus</i>	<i>D. Padi</i>
<i>D. Chionanthi</i>	<i>D. Prunastri</i>
<i>Fraxinus</i>	<i>Sorbus</i>
<i>D. Tulasnei</i>	<i>D. Ariac</i>
<i>Hamamelis</i>	<i>Tsuga</i>
<i>D. Hamamelidis</i>	<i>D. balsamea</i>
<i>Ilex</i>	<i>Viburnum</i>
<i>D. Peckiana</i>	<i>D. Viburni</i>
<i>Libocedrus</i>	
<i>D. Libocedri</i>	

## DOUBTFUL AND EXCLUDED SPECIES

Many fungi have been described in *Dermea* which do not truly belong there. An attempt has been made to bring together all the *Dermea* names in the literature and to account for them. Where possible the true relationships of the fungi will be indicated below, but with many of them it is impossible to even guess at their position until they have been more critically studied.

*D. abietina* Auersw. Tauschverein. 1865. This name is cited by Rehm (1889) as a synonym of *Pezicula eucrita* Karst. I have seen a specimen so labelled in Rab. Fung. Eur. 1027, but could not find any fungus except what may have been the remains of a few old apothecia of a *Pezicula*. I have not seen any description.

*D. abietina* Vel. Mon. Disc. Bohem. p. 65, 1934. This species is known to me only by the description. It was said to be on *Abies* and the description agrees fairly well with *D. balsamea*, but it would be necessary to see authentic specimens before placing it in synonymy.

*D. acericola* (Peck) Cooke, Grev. 3: 137, 1875 = *Pezicula acericola* (Peck) Sacc. Atti Ist. Ven. VI, 3: 725, 1885.

*D. acicola* Briard & Sacc. Rev. Mycol. 7: 159, 1885. This species was described as occurring on leaves of *Juniperus* and this habitat would exclude it from *Dermea*. I have seen no material.

*D. Alni* Rehm, Rab. Krypt.-Fl. I, 3: 252, 1889 = *Pezicula Alni* Rehm, Ber. Bayer. Bot. Ges. 13: 199, 1912.

*D. amoena* Tul. Bot. Zeit. 11: 54, 1853 = *Pezicula amoena* Tul. Sel. Fung. Carp. 3: 184, 1865.

*D. atra* Vel. Mon. Disc. Bohem. p. 65, 1934. This species, which was described on *Pinus*, is excluded from *Dermea* by reason of the long, cylindric, finally eight celled spores. Velenovsky described it under *Dermea* in the text but illustrated it as *Durella atra*.

*D. aureo-tincta* Rehm, Hedw. 39: 84, 1900. Specimens in the Farlow Herbarium bearing this name are a large species of *Encoelia*. No other material has been seen.

*D. australis* (Speg.) Sacc. Syll. Fung. 8: 554, 1889. This species was originally described as a *Cenangium* occurring on *Fagus*. The description does not suggest *Dermea* and no material has been seen.

*D. australis* Rehm, Rab. Krypt.-Fl. I, 3: 254, 1889 = *Pezicula australis* Rehm, Ber. Bayer. Bot. Ges. 13: 201, 1912.

*D. Betulae* Rehm, Rab. Krypt.-Fl. I, 3: 1221, 1896 = *Pezicula Betulae* Rehm, Ber. Bayer. Bot. Ges. 13: 200, 1912.

*D. blumenaviensis* P. Henn. Hedw. 41: 18, 1902. This species was described on rotten wood from Brazil. The description does not suggest a *Dermea*, but no material has been seen.

*D. brunneo-pruinosa* Zeller, Mycologia 26: 291, 1934 = *Pestalopezia brunneo-pruinosa* Seaver, Mycologia 34: 300, 1942. This species is very close to *Velutaria* but was placed in a distinct genus by Seaver on the basis of the conidial stage. It occurs on *Gaultheria Shallon*.

*D. caespitosa* Fuckel, Synb. Myc. p. 277, 1870. This fungus was described as occurring on *Corylus*, but no authentic material has been seen. The description suggests an *Encoelia*. The spores would exclude it from *Dermea*.

*D. carnea* Cke. & Ell. Grev. 5: 32, 1876 = *Pezicula carnea* Rehm, Ber. Bayer. Bot. Ges. 13: 199, 1912.

*D. carpineae* (Pers.) Fr. Summ. Veg. Scand. p. 362, 1849 = *Pezicula carpineae* Tul. Sel. Fung. Carp. 3: 183, 1865.

*D. Cenangium* (DeNot.) Rehm, Rab. Krypt.-Fl. I, 3: 1256,

1896. This species, occurring on *Rhododendron*, is apparently a *Velutaria* but no authentic specimens have been seen.

*D. cinnamomea* (DC.) B. & Br. Ann. & Mag. Nat. Hist. ser. 5, 7: 131, 1881 = *Pezicula cinnamomea* Sacc. Syll. Fung. 8: 311, 1889.

*D. cinnamomea* Cke. & Peck, N. Y. St. Mus. Ann. Rep. 28: 67, 1876 = *Ocellaria ocellata* (Pers.) Schroet. Krypt.-Fl. Schles. III, 2: 150, 1908. Part of the type in the Durand Herbarium 3788 has been seen.

*D. conigena* Phill. Grev. 9: 106, 1881. No material of this fungus has been seen but the color would exclude it from *Dermea*. It was described as occurring on cones of *Abies*.

*D. constipata* Starb. Bih. K. Svensk. Vet. Akad. Handl. 25: 13, 1899. This fungus was described from Brazil on an unidentified host. The description does not suggest *Dermea* but no material has been seen.

*D. Corni* Phill. & Hark. Grev. 13: 22, 1884 = *Pezicula Corni* Petr. Ann. Myc. 20: 197, 1922.

*D. corticola* Arnaud, Rev. Path. Vég. 10: 30, 1923 = *Pezicula corticola* Nannf. Nova Acta Reg. Soc. Sci. Upsal. ser. 4, 8: 94, 1932.

*D. Coryli* Tul. Bot. Zeit. 11: 54, 1853 = *Pezicula Coryli* Tul. Sel. Fung. Carp. 3: 183, 1865.

*D. Crataegi* Jaap, Abh. Bot. Ver. Prov. Brandbg. 52: 127, 1910. From specimens in Jaap Fung. Sel. Exs. 413 this is a *Pezicula* resembling *P. crataegicola* (Dur.) in gross appearance but with much smaller asci and spores. There is no valid name available for this fungus at present.

*D. crataegicola* Durand, Journ. Mycol. 10: 100, 1904. The type of this species in the Durand Herbarium 2453 has been examined. It is a rather dark colored *Ocellaria*-like fungus, with large asci and ascospores. Its affinities seem to be closer to *Pezicula* than to *Dermea* and it should be called *Pezicula crataegicola* (Durand) n. comb.

*D. Craterium* Schw. Trans. Amer. Phil. Soc. II, 4: 237, 1822 = *Urnula Craterium* Fries, Nova Acta Soc. Sci. Upsal. III, 1: 122, 1851.

*D. crypta* Cooke, Grev. 16: 70, 1888. The description of this species suggests a *Pezicula*, but no material has been seen.

*D. cucurbitaria* Cooke, in Ellis N. Amer. Fung. 68, 1878 = *Triblidium cucurbitaria* Rehm, Ber. Naturh. Ver. Augsburg 26: 78, 1881.

*D. Cydoniae* Schw. Syn. Fung. Amer. Bor. p. 237, 1832. A portion of the type of this species was kindly loaned by Mr. J. A. Stevenson. The fungus is not a discomycete. Some old fruiting bodies that may have been pycnidia or possibly perithecia were present, but no spores were found. The name should be dropped.

*D. dimorpha* Seaver, Mycologia 16: 8, 1924. Authentic specimens of this species were kindly loaned by Dr. Seaver. The fungus is certainly not a *Dermea* but it is difficult to place it satisfactorily. It seems to be more closely allied to *Encoelia*, but it is not a typical member of this genus either. It should be compared with authentic material of *Cenangium episphaeria* Schw. Two specimens have been examined in the Farlow Herbarium under this name which were collected by Rick in Brazil. One is labelled "*Dermatea episphaeria*" but this combination does not appear to have been published. These two specimens are the same as Seaver's species, but no authentic Schweinitz specimen has been seen.

*D. dissepta* Tul. Bot. Zeit. 11: 54, 1853 = *Pezicula dissepta* Tul. Sel. Fung. Carp. 3: 187, 1865.

*D. dryina* Cooke apud Phillips, Man. Brit. Disc. p. 340, 1893 = *Pezicula dryina* Sacc. Syll. Fung. 8: 313, 1889. A specimen of this fungus in the Durand Herbarium 145 has been examined. It occurs on *Quercus* and is a rather distinctive species, not fitting well in either *Dermea* or *Pezicula*, but closer to the latter.

*D. endoneura* Har. & Pat. Bull. Mus. d'hist. nat. 8: 132, 1902. This species was described from Japan on an unidentified host. No material has been seen but the description does not suggest *Dermea*.

*D. Eucalypti* Cke. & Hark. Grev. 9: 130, 1881. A specimen marked "type" was kindly loaned from the Herbarium of the California Academy of Science. It was scanty and in poor-condition and it was not possible to place the fungus satisfactorily from this material. It did not appear to be a *Dermea*.



*D. eucrita* (Karst.) Rehm, Rab. Krypt.-Fl. I, 3: 255, 1889 = *Pezicula eucrita* Karst. Monogr. Pez. Fenn. p. 147, 1869. This is probably a synonym of *P. livida* (Berk. & Br.) Rehm, Ber. Naturh. Ver. Augsburg 26: 112, 1881.

*D. Fagi* Phill. Grev. 15: 114, 1887 = *Pezicula Fagi* Boud. Disc. d'Eur. p. 159, 1907.

*D. fascicularis* Fries, Summ. Veg. Scand. p. 362, 1849 = *Encoelia fascicularis* Karst. Myc. Fenn. 1: 217, 1871.

*D. ferruginea* (Cke. & Ell.) Rehm, Ann. Myc. 2: 353, 1904. Type material of this species in the Farlow Herbarium has been seen, but it was very scanty and in poor condition. The host is not identified. It appeared to be a *Pezicula*, or at least closer to that genus than to *Dermia*.

*D. ficicola* Pat. Journ. de Bot. 11: 346, 1897. This species is known to me only from the description in Saccardo, Syll. Fung. 14: 795, 1899, and it cannot be satisfactorily placed. It is doubtful that it belongs in this genus. It is said to occur on *Ficus*.

*D. fissa* Fries, Summ. Veg. Scand. p. 362, 1849. No material of this species has been seen. It is said to occur on *Corylus* and may be an *Encoelia*.

*D. flavocinerea* Phillips, Grev. 7: 23, 1878. It was described as occurring on chips of wood. No material has been seen but from the description it would be excluded from *Dermia*.

*D. Frangulae* (Pers.) Tul. Sei. Fung. Carp. 3: 161, 1865 = *Pezicula Frangulae* Fuckel, Symb. Myc. p. 279, 1870.

*D. fumosa* Cke. & Phill. Grev. 8: 64, 1879. It was described as occurring on rotten wood in New Zealand. No material has been seen and the description does not suggest *Dermia*.

*D. furfuracea* (Roth) Fries, Summ. Veg. Scand. p. 362, 1849 = *Encoelia furfuracea* Karst. Myc. Fenn. 1: 218, 1871.

*D. fusispora* Ell. & Ev. Proc. Acad. N. S. Philad. 45: 148, 1893. This species was discussed under *D. molliuscula*. It is a synonym of *Pezicula citrinella* Rehm, Ber. Bayer. Bot. Ges. 13: 199, 1912, but it is not a true *Pezicula*. Seaver (1945) has placed it in *Godronia* but except for the superficial similarity of the elongated spores it shows no affinities with this genus.

*D. heteromera* (Mont.) Bres. apud Rick in Broteria Cienc. Nat.

1: 91, 1932 = *Encoelia heteromera* (Mont.) Nannf. Trans. Brit. Myc. Soc. 23: 239, 1939.

*D. Houghtonii* Phillips, Grev. 6: 24, 1877. Specimens of the fungus in Phill. Elv. Brit. 144 and Cooke Fung. Brit. Exs. 660 have been examined. It belongs in *Pezicula* rather than *Dermea* and should be designated ***Pezicula Houghtonii*** (Phill.) n. comb. It occurs on Portuguese Laurel, *Prunus lusitanica*.

*D. inclusa* Peck, N. Y. St. Mus. Ann. Rep. 30: 62, 1878 = *Ocellaria ocellata* (Pers.) Schroet. Krypt.-Fl. Schles. III, 2: 150, 1908. Part of the type in the Durand Herbarium 6073 has been seen.

*D. juniperina* Ell. Amer. Nat. 17: 192, 1883 = *Chloroscypha juniperina* Seaver, Mycologia 23: 250, 1931:

*D. Kalmiae* (Peck) Cooke, Disc. U. S. 2: 23, 1875. Two specimens identified as this species have been seen, a specimen on *Vaccinium* in the Farlow Herbarium and a specimen in Ell. N. Amer. Fung. 147. In both of these the material was in poor condition and satisfactory mounts could not be obtained. Rehm (Ann. Myc. 2: 353, 1904) placed it in *Gorgoniceps* after an examination of the specimen in N. Amer. Fung. 147, but he described the spores as  $25-30 \times 1 \mu$  whereas the original description gave them as  $10 \times 5 \mu$ . This would suggest that the Ellis specimen was not correctly identified. It was also on *Vaccinium* whereas the type was said to be on *Kalmia*. The identity of this fungus is in doubt, but the original description suggests a *Volutaria*.

*D. laricicola* (Fuckel) Rehm, Rab. Krypt.-Fl. I, 3: 254, 1889 = *Pezicula laricicola* Fuckel, Symb. Myc. p. 279, 1870. This fungus appears to be morphologically indistinguishable from *P. livida* (B. & Br.) Rehm, Ber. Naturh. Ver. Augsburg 26: 112, 1881.

*D. lilacina* (Bres.) Rehm, Rab. Krypt.-Fl. I, 3: 1255, 1896. It was described as occurring on *Alnus*. No material has been seen but the description does not suggest *Dermea*.

*D. livida* (B. & Br.) Phill. Man. Brit. Disc. p. 340, 1893 = *Pezicula livida* Rehm, Ber. Naturh. Ver. Augsburg 26: 112, 1881.

*D. lobata* Ell. Bull. Torrey Club 6: 108, 1876. Through the kindness of Dr. Seaver it was possible to examine the type and other specimens in the herbarium of the New York Botanical Gar-

den. The type is on *Quercus* but other specimens on *Andromeda* had also been identified as this species by Ellis. All of the material on *Quercus* was immature and no asci or spores could be found. The young apothecia suggested a *Velutaria* or *Encoelia* in general appearance. The specimens on *Andromeda* were in good fruit and were certainly a species of *Velutaria* but, in my opinion, are not the same species as the specimens on *Quercus*. The young apothecia are smaller and less globose than those on *Quercus*, and are a little paler colored. The paraphyses are rounded and enlarged at the tips whereas those of the *Quercus* specimens in the immature material examined appeared to be pointed. In this respect they suggested *Cenangium quercicolum* Romell which has lance-shaped paraphyses. The apothecia of this species, from specimens in Romell Fung. Exs. Scand. 199 and Vestergren Microm. Rar. Sel. 213, are similar to those of *D. lobata* in gross appearance, but the spores and paraphyses do not agree with Ellis' original description. The North American species on *Quercus* should be re-studied in fresh condition and the characters of the ascospores and paraphyses determined with certainty. If, as seems possible, Ellis' original description was compounded from both the *Quercus* and *Andromeda* specimens, the name must be regarded as a *nomen confusum* and dropped.

*D. macrospora* Clements, Bull. Torrey Club 30: 87, 1903 = *Ocellaria ocellata* (Pers.) Schroet. Krypt.-Fl. Schles. III, 2: 150, 1908.

*D. Magnoliae* (Berk. & Curt.) Cooke, Grev. 7: 48, 1878. A specimen in Rav. Fung. Amer. 70 on *Persea* has been examined, and agrees with the original description. The apothecia are like a large *Dermea* in gross appearance, but the asci are like those of an *Ocellaria* and the ascospores are also like those of an *Ocellaria* but are brown. It is not possible to place this species satisfactorily at present but it should be excluded from *Dermea*.

*D. microspora* Vel. Mon. Disc. Bohem. p. 65, 1934. No material of this species has been seen but it should be compared with the one described as *D. pinicola* in this paper. It was said to occur on *Pinus* and the description suggests *D. pinicola*. If they prove to be identical, Velenovsky's name is valid.

*D. micula* (Fr.) Rehm, Rab. Krypt.-Fl. I, 3: 261, 1889. This is an interesting fungus occurring on *Rhamnus*. It has apothecia like a *Pezicula*, but has subfiliform conidia like a *Micropera*, and is similar to *P. alnicola* Groves (Mycologia 32: 120, 1940) in this respect. This species has been studied in culture and a detailed account will be published later. It should be placed in *Pezicula*.

*D. minuta* Peck, N. Y. St. Mus. Ann. Rep. 32: 48, 1879 = *Pezicula minuta* Peck, N. Y. St. Mus. Bull. 2: 21, 1887. Part of the type in the Durand Herbarium 6075 has been examined.

*D. minuta* Vel. Mon. Disc. Bohem. p. 63, 1934. This species was described as occurring on *Salix*. No material has been seen but the description does not suggest *Dermea*. The name is invalid as it is a later homonym of *D. minuta* Peck.

*D. Mori* Peck, N. Y. St. Mus. Bull. 157: 46, 1912. It has not been possible to see any specimens of this species which was described from Kansas as occurring on *Morus*. It cannot be placed with certainty from the description, but there is nothing to definitely exclude it from *Dermea*.

*D. mycophaga* Mass. Kew Bull. Misc. Inf. 22: 218, 1908. It was described as occurring on *Xylaria* in the Straits Settlements. No material has been seen but the description does not suggest *Dermea*.

*D. myrtikina* Karst. apud Vel. Mon. Disc. Bohem. p. 64, 1934 = *Pezicula myrtillina* Karst. Myc. Fenn. 1: 165, 1871.

*D. nectrioides* Phill. Man. Brit. Disc. p. 340, 1893. This species was described as occurring on cones of *Pinus sylvestris*. No material has been seen but it seems close to *D. conigena* Phill.

*D. nodulariformis* Rea, Trans. Brit. Myc. Soc. 5: 256, 1916. No material of this fungus has been seen but the description does not suggest *Dermea*. The host was not identified.

*D. olivacea* Otth, Bern. Mitth. p. 40, 1868. No material has been seen. It was described as occurring on *Prunus* and the description does suggest a *Dermea*, but without specimens it is impossible to decide whether it is a synonym of one of the three species recognized on this host.

*D. olivacea* Ellis, Bull. Torrey Club 6: 133, 1876. Through the kindness of Dr. F. J. Seaver it was possible to examine the type

and other specimens identified as this fungus in the Herbarium of the New York Botanical Garden. The type is on *Ilex*, and two other collections on *Ilex* and the specimen in Ellis N. Amer. Fung. 851 agree closely with it. The fungus is not a *Dermea*. It is closer to *Pezicula* and probably belongs among the *Ocellaria*-like species of this genus but should be studied in fresh condition before it is finally placed. A scanty collection on *Andromeda* was also referred to this species, but although it resembled it in gross appearance, the asci were slightly narrower and the ascospores a little longer. Another collection, said to be on "ash?", was also similar in gross appearance but differed quite markedly in the shape of the asci. In addition, a specimen in the Farlow Herbarium on *Vaccinium* also differed from the type in the shape of the asci. I am of the opinion that there is a group of species which have been lumped under this name, but it will be necessary to study them in the fresh condition and in culture before they can be placed satisfactorily. The specific name is invalid as it is a later homonym of *D. olivacea* Oth.

*D. olivacea* Kirschst. Verh. Bot. Ver. Brandbg. 18: 40, 1906 = *Dermatella hortorum* Kirschst. Ann. Myc. 34: 210, 1936. Kirschstein gave this species a new name because he recognized that it was a later homonym of *D. olivacea* Oth. No material has been seen but it should be compared with *Pezicula plantarium* Wollenweber.

*D. olivascens* Rehm, Ann. Myc. 5: 80, 1907. From the specimens in Rehm Ascom. 1686 this is a *Pezicula* and is morphologically indistinguishable from *P. crataegicola* (Durand).

*D. Ononidis* Vel. Mon. Disc. Bohem. p. 64, 1934. No material of this species has been seen but the description does not suggest a *Dermea* and its occurrence on herbaceous plants would seem to exclude it from this genus.

*D. pallidula* Cke. Grev. 16: 70, 1888 = *Pezicula pallidula* (Cke.) Rehm, Ber. Bayer. Bot. Ges. 13: 199, 1912.

*D. palmicola* Pat. Bull. Soc. Myc. Fr. 28: 35, 1912. This fungus was described on palms from French Guinea. No material has been seen but the description suggests that it is closer to *Encoelia* than to *Dermea*.

*D. parasitica* (Wint.) Höhn. Fragm. z. Myk. no. 455, 1909. No material has been seen, but its habitat on leaves of *Melastomataceae* would appear to exclude it from *Dermea*.

*D. pelidna* Kalchbr. & Cke. Grev. 9: 25, 1880. This was described from South Africa on an unknown host. No material has been seen but the description suggests that it is closer to *Encoelia* than to *Dermea*.

*D. phyllophila* Peck, N. Y. St. Mus. Ann. Rep. 31: 47, 1879. It has not been possible to see authentic material of this fungus, but specimens agreeing with the original description have been studied in the fresh condition and cultured. It occurs on leaves of *Abies* and is probably closer to *Mollisia* than to *Dermea*.

*D. Piceae* (Pers.) Rehm, Rab. Krypt.-Fl. I, 3: 257, 1889. It has not been possible to see authentic material, but specimens on leaves of *Abies grandis* which agree closely with Rehm's description were received from Dr. John Ehrlich. The fungus is not a *Dermea* but cannot be satisfactorily placed at present.

*D. Pini* Otth, Bern. Mittheil. p. 40, 1868. This was described as occurring on *Picea excelsa*. It is known to me only through the description in Saccardo Syll. Fung. 14: 795, 1899. The description is incomplete but it does suggest a true *Dermea* species.

*D. Pini* Phill. & Hark. Grev. 13: 22, 1884 = *Cenangium ferruginosum* Fr. Syst. Myc. 2: 187, 1822. Through the kindness of the California Academy of Science it was possible to examine the type of this species.

*D. polygonia* (Fckl.) Rehm, Rab. Krypt.-Fl. I, 3: 263, 1889. It was originally described as occurring on *Pyrus Malus*. In the original description Fuckel stated that the asci were many-spored suggesting *Tympanis*, but the specimen in Fuckel Fung. Rhen. 2677 has eight spored asci. However, it is not a *Dermea*. The identity of this fungus is obscure. Saccardo (Syll. Fung. 8: 556 and 579, 1889) took the view that Fuckel had two fungi. He made the combination *Tympanis polygonia* for the fungus described by Fuckel and retained the name *Cenangium polygonium* for the fungus in the exsiccatus. Study of fresh material is essential before the species can be satisfactorily placed.

*D. populina* Schw. In Kelsey, Journ. Myc. 5: 82, 1889. This

name appeared in a list of fungi of Helena, Montana. Schweinitz does not appear to have made such a combination and it is not clear whether it was intended to designate the following species or *Cenangium populinum* Schw. Syn. p. 239, 1832. The name has no standing.

*D. populnea* Schw. Syn. Fung. Amer. Bor. p. 237, 1832. Through the kindness of Mr. J. A. Stevenson it was possible to examine part of the type of this species. It is not a discomycete. The material was not in good condition but appeared to be fruiting bodies of a pyrenomycete. The name should be dropped. Saccardo, Syll. Fung. 8: 576, 1889, wished to place this species in *Cenangium* and in order to avoid creating a homonym of *C. populneum* Pers. he gave it a new name, *C. Schweinitzii*. This name, also, should be dropped.

*D. pruinosa* (Farl.) Petr. Ann. Myc. 20: 196, 1922 = *Pezicula pruinosa* Farl. Mycologia 14: 102, 1922.

*D. Pseudoplatani* Phill. Grev. 17: 45, 1888. This fungus is unquestionably a *Pezicula* and appears to be very close to or perhaps identical with *P. carnea* (Cke. & Ell.) Rehm, Ber. Bayer. Bot. Ges. 13: 199, 1912.

*D. puberula* Durand, Journ. Myc. 10: 101, 1904. Through the kindness of Professor H. M. Fitzpatrick the type of this fungus has been examined. It is not a *Dermea* but cannot be satisfactorily placed at present.

*D. pulcherrima* Fckl. Symib. Myc. Nachtr. 2: 56, 1873. No material has been seen, but it seems probable that the name was based on unusually large apothecia of *D. Cerasi*.

*D. pulchra* Starb. Arkiv. f. Bot. 2: 6, 1904. This was described on an unknown host from Brazil. From the description it appears to be closer to *Encoelia* than to *Dermea*.

*D. pulveracea* (A. & S.) Rehm, Ber. Bayer. Bot. Ges. 13: 197, 1912. The concept of this species is very much confused. It is evident from the literature that various fungi on different hosts have passed under this name. No authentic material has been seen and it is impossible at present to say what it may be. It was originally described as occurring on *Betula*. The original description is slightly suggestive of a *Tympanis*, but the figure might be a *Ciboria*.

*D. purpurascens* Ell. & Ev. Journ. Myc. 4: 100, 1888 = *Pezicula purpurascens* Seaver, Mycologia 37: 414, 1942.

*D. purpurea* (Hedw.) Fr. Summ. Veg. Scand. p. 362, 1849. This species is known to me only through the description in Saccardo Syll. Fung. 8: 568, 1889. This does not suggest a *Dermea* but it is not possible to say what the fungus might be.

*D. purpurea* Ell. Bull. Torrey Club 6: 108, 1876 = *D. viburnicola* Ell. N. Amer. Fung. 397, 1879. The name was a later homonym of *D. purpurea* (Hedw.) Fr. and was changed by Ellis on the specimen issued in N. Amer. Fung. It was later changed again by Saccardo in Syll. Fung. 8: 566, 1889 to *Cenangium Ellisii*. The species belongs in *Encoelia*.

*D. quercina* (Fckl.) Rehm, Rab. Krypt.-Fl. I, 3: 1257, 1896 = *Pezicula quercina* Fckl. Symb. Myc. p. 279, 1870.

*D. radulicola* Fuckel, Symb. Myc. p. 278, 1870. Nannfeldt in Trans. Brit. Myc. Soc. 20: 204, 1936, stated that the type of *Peziza Johnstoni* Berk. was the same as this species and Berkeley's name is the earlier. The fungus appears to be an *Encoelia* judging from specimens in Fckl. Fung. Rhen. 2073, Rehm Ascom. 1902, and a specimen ex Herb. Barbey-Boissier 1127.

*D. rhabarbarina* (Berk.) Phill. Man. Brit. Disc. p. 343, 1893 = *Pezicula rhabarbarina* Tul. Sel. Fung. Carp. 3: 183, 1865.

*D. Rhododendri* Rehm, Ber. Naturh. Ver. Augsburg 26: 29, 1881. This is apparently a *Velutaria* that Rehm later stated to be identical with *D. Cenangium* (Ces.) DeNot. It is not the same fungus as *Velutaria Rhododendri* (Ces.) Rehm (which is not a true *Velutaria*).

*D. rhododendricola* Rehm, Rab. Krypt.-Fl. I, 3: 254, 1889 = *Pezicula rhododendricola* Rehm, Ber. Bayer. Bot. Ges. 13: 200, 1912.

*D. Rickiana* Rehm, Ann. Myc. 6: 319, 1908. No material of this species, which was described from Brazil, has been seen but the description does not suggest a *Dermea*.

*D. Rosae* Rehm, Rab. Krypt.-Fl. I, 3: 259, 1889 = *Pezicula Rosae* Sacc. Mich. 1: 59, 1877.

*D. rosella* Rehm, Rab. Krypt.-Fl. I, 3: 257, 1889 = *Pezicula citrinella* Rehm. See discussion of *D. fusispora* Ell. & Ev.



*D. Rubi* (Lib.) Rehm, Rab. Krypt.-Fl. I, 3: 258, 1889 = *Pesicula Rubi* (Lib.) Niessl, Rab. Fung. Eur. 2122, 1876.

*D. rubiginosa* Fr. Summ. Veg. Scand. p. 362, 1849. This fungus is known to me only through the description in Saccardo Syll. Fung. 8: 569, 1889. It was described from Russia, and was said to be on rotten wood. The description does not suggest *Dermea*.

*D. rufa* Cooke, Grev. 8: 72, 1879. This species was described as occurring on bark in Natal, Africa. No specimen has been seen, but the description does not suggest *Dermea*.

*D. Sabalidis* Ell. & Mart. Amer. Nat. 18: 1147, 1884. No specimen of this species has been seen, but the habitat and the small asci and ascospores make it improbable that it belongs in *Dermea*.

*D. seriata* (Fr.) Tul. Sel. Fung. Carp. 3: 160, 1865 = *Scleroderris seriata* (Fr.) Rehm, Rab. Krypt.-Fl. I, 3: 211, 1889.

*D. simillima* Ell. & Ev. Proc. Acad. Nat. Sci. Philad. 1893: 451, 1894 = *Pesicula carnea* (Cke. & Ell.) Rehm, Ber. Bayer. Bot. Ges. 13: 199, 1912.

*D. sparsa* P. Henn. Hedw. 41: 19, 1902. This species was described on leaves of palms from Brazil. No material has been seen but the description does not suggest *Dermea*.

*D. Spiraeae* Schw. Syn. Fung. Amer. Bor. p. 237, 1832. Through the kindness of Mr. J. A. Stevenson it was possible to examine the type. The specimen was very scanty and contained only some old fruiting bodies which might be either pycnidia or perithecia. The fungus is certainly not a discomycete and the name should be dropped.

*D. stegiioides* Speg. Mich. 1: 471, 1879. This species was described as occurring on *Quercus sessiliflora* in Italy. No material has been seen but the description does not suggest *Dermea*.

*D. Sydowii* Rehm, in Syd. Myc. March. 379, 1882. The type, which was found on *Lupinus luteus*, has been examined. It is closer to *Encoelia* than to *Dermea*, but should be studied further.

*D. Syringae* Rehm, Asc. Lojk. p. 20, 1873. This fungus was described as occurring on *Syringa vulgaris* in Hungary. No material has been seen but the description does not suggest *Dermea*.

*D. tabacina* Cooke, Bull. Buff. Soc. Nat. Sci. 3: 24, 1875 = *Dermateopsis tabacina* Nannf. Nova Acta Soc. Sci. Upsal. IV, 8: 89, 1932.

*D. tetraspora* Ell. Bull. Torrey Club 6: 108, 1876. Authentic specimens of this species in the Farlow Herbarium have been examined. The apothecia suggest *Velutaria*, but it is remarkable for the large four-spored asci and very large almost globose spores. It is not a *Dermea*, but should be studied further.

*D. tijuensis* P. Henn. Hedw. 43: 91, 1904. This species was described as occurring on *Tijuca* in Brazil. No material has been seen but the description does not suggest a *Dermea*.

*D. tiliacea* Fr. Summ. Veg. Scand. p. 362, 1849 = *Encoelia tiliacea* Karst. Myc. Fenn. 1: 218, 1871.

*D. turicensis* (Rehm) Vel. Mb. Disc. Bohem. p. 63, 1934. No material has been seen but the description and figures of Velenovsky do not suggest *Dermea*. It has been reported on *Juniperus*, *Picea*, and *Corylus* so probably more than one fungus has been confused under this name.

*D. Ulicis* Cooke, Grev. 3: 186, 1875. This was described as occurring on *Ulex* in England. No material has been seen but the description suggests *Encoelia*, and Nannfeldt, who examined the type, stated in Trans. Brit. Myc. Soc. 23: 249, 1939 that it belonged in this genus.

*D. Ulmi* (Tul.) Fckl. Symb. Myc. Nachtr. 2: 56, 1873 = *Encoelia siparia* (B. & Br.) Nannf. Trans. Brit. Myc. Soc. 20: 196, 1936.

*D. umbrina* Cke. & Mass. Grev. 21: 72, 1893. This species was described as occurring on *Ulex* in England. No material has been seen but the description suggests *Encoelia* rather than *Dermea*.

*D. vernicosa* (Fckl.) Rehm, Rab. Krypt.-Fl. I, 3: 262, 1889. This species was discussed under *D. Cerasi*. Its identity is not known.

*D. versiformis* (Alb. & Schw.) Rehm, Ber. Bayer. Bot. Ges. 13: 197, 1912 = *Pezicula Frangulae* (Pers.) Fckl. Symb. Myc. p. 279, 1870. This name was based on the conidial stage of *P. Frangulae*.

*D. viburnicola* Ell. N. Amer. Fung. 397, 1879. This was discussed under *D. purpurea* Ell.

*D. viridis* Vel. Mon. Disc. Bohem. p. 399, 1934. This fungus was described as occurring on *Quercus*. No material has been seen but the description does not suggest *Dermea*.

*D. Xanthoxyli* Peck, N. Y. St. Mus. Ann. Rep. 31: 47, 1879.

Through the kindness of Professor H. M. Fitzpatrick it was possible to examine part of the type of this species in the Durand Herbarium. The apothecia were growing on the stroma of *Thyronectria pyrrhocolora* (Auersw.) Sacc. No asci or spores were found in this material but the fungus is not a *Dermeca*.

#### ACKNOWLEDGMENTS

In presenting this paper I wish to tender my sincere thanks to the following, without whose invaluable assistance and friendly co-operation these studies would not have been possible. I am especially indebted to Professor H. S. Jackson for his continued interest and helpful criticisms and suggestions throughout the course of the work and in the preparation of the manuscript. Dr. D. H. Linder has made available the specimens in the Farlow Herbarium and Professor H. M. Fitzpatrick many specimens in the Durand Herbarium; Dr. F. J. Seaver and Mr. J. A. Stevenson have loaned type and authentic specimens. Collections of fresh and dried material have been received from many mycologists including Dr. L. O. Overholts, Dr. L. E. Wehmeyer, Dr. W. L. White, Dr. G. D. Darker, Miss E. K. Cash, Mr. H. E. Parks, Dr. S. M. Pady, and Dr. R. F. Cain. Constructive criticism and other assistance in preparation of the manuscript have been received from Dr. F. L. Drayton, Mr. I. L. Connors, and Dr. A. J. Skolko. Dr. D. P. Rogers has given helpful advice with some of the nomenclatural problems.

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## EXPLANATION OF FIGURES

FIGS. 1-26. Photographs of apothecia and conidial stages of *Dermea* species. M = 4 × approx.

FIG. 1. Apothecia of *D. Cerasi*, JWG 122; 2. Conidial stage of *D. Cerasi*, JWG 86; 3. Apothecia of *D. Padi*, JWG 460; 4. Conidial stage of *D. Padi*, Krieg. Fung. Sax. 2388; 5. Apothecia of *D. Prunastri*, DAOM ex USDA 1402; 6. Conidial stage of *D. Prunastri*, DAOM 3789; 7. Apothecia and conidial stage of *D. Libocedri*, JWG 691; 8. Apothecia of *D. balsamea*, JWG 45; 9. Conidial stage of *D. balsamea*, JWG 281; 10. Apothecia of *D. Chionanthi*, Fung. Columb. 2423; 11. Apothecia of *D. piceina*, JWG 795; 12. Conidial stage and immature apothecia of *D. piceina*, JWG 788; 13. Apothecia of *D. Tulasnei*, JWG 403; 14. Conidial stage of *D. Tulasnei*, JWG 468; 15. Apothecia of *D. pinicola*, JWG 402; 16. Apothecia and conidial stage of *D. acerina*, DAOM 5310; 17. Apothecia of *D. Hamamelidis*, type of *Dermatella Hamamelidis* Ell. & Ev. ex F; 18. Apothecia of *D. Peckiana*, JWG 428; 19. Conidial stage of *D. bicolor*, DAOM 7935; 20. Apothecia of *D. bicolor*, JWG 725; 21. Apothecia and conidial stage of *D. molliuscula*, DAOM 5317; 22. Apothecia of *D. Ariae*, JWG 406; 23. Conidial stage of *D. Ariae*, JWG 406; 24. Apothecia and conidial stage of *D. Viburni*, DAOM 7937; 25. Conidial stage of *D. Hamamelidis*, JWG 162; 26. Conidial stage of *D. Peckiana*, DAOM 3781.

FIGS. 27-41. Photographs of freehand sections of conidial fruiting bodies of *Dermea* species. M = 52 × approx.

FIG. 27. *D. Cerasi*, JWG 28; 28. *D. Prunastri*, DAOM 4713; 29. *D. Padi*, JWG 460; 30. *D. balsamea*, JWG 10; 31. *D. Libocedri*, JWG 691; 32. *D. piceina*, JWG 788; 33. *D. bicolor*, JWG 715; 34. *D. Ariae*, JWG 180; 35. *D. Peckiana*, DAOM 3781; 36. *D. acerina*, JWG 134; 37. *D. Tulasnei*, JWG 305; 38. *D. Viburni*, JWG 230; 39. *D. molliuscula*, JWG 278; 40. *D. Chionanthi*, JWG 748; 41. *D. Hamamelidis*, JWG 162.

FIGS. 42-57. Drawings of asci, ascospores, conidia, and microconidia of *Dermea* species.

FIG. 42. *D. Cerasi*—a, asci and ascospores—b, conidia and microconidia; 43. *D. Prunastri*—a, asci and ascospores—b, conidia and microconidia; 44. *D. Padi*—a, asci and ascospores—b, conidia and microconidia; 45. *D. bicolor*—a, asci and ascospores—b, conidia and microconidia; 46. *D. Hamamelidis*—a, asci and ascospores—b, conidia; 47. *D. molliuscula*—a, asci and ascospores—b, conidia and microconidia; 48. *D. Chionanthi*—a, asci and ascospores—b, conidia; 49. *D. Viburni*—a, asci and ascospores—b, conidia and microconidia; 50. *D. acerina*—a, asci and ascospores—b, conidia and microconidia; 51. *D. pinicola*—a, asci and ascospores—b, conidia; 52. *D. piceina*—a, asci and ascospores—b, conidia; 53. *D. Ariae*—a, asci and ascospores—b, conidia and microconidia; 54. *D. balsamea*—a, asci and ascospores—b, conidia and microconidia; 55. *D. Tulasnei*—a, asci and ascospores—b, conidia and microconidia; 56. *D. Peckiana*—a, asci and ascospores—b, conidia and microconidia; 57. *D. Libocedri*—a, asci and ascospores—b, conidia.



# **CHROMOBLASTOMYCOSIS. SOME OBSERVATIONS ON THE TYPES OF THE DISEASE IN SOUTH AFRICA**

F. W. SIMSON<sup>1</sup>

In 1943 a report on six cases of chromoblastomycosis occurring in the Union of South Africa was published by Simson, Harington and Barnetson (1) and among these cases the causal fungus was isolated in two instances. Since that date six additional cases of the disease have been diagnosed by the writer and from lesions in four of them the organisms have been recovered and classified.

Among all twelve cases diagnosed to date, including those published in 1943, eleven showed lesions which were primarily confined to a lower limb. In the remaining case the disease affected the skin in the region of the anus. Ten of the subjects affected were Africans and two were Europeans.

Unfortunately no opportunity was afforded for cultivating the organism from lesions in four of the first series or from two in the second series of cases.

An analysis of the clinical pictures presented by these twelve cases of chromoblastomycosis shows that the lesions manifested themselves as two distinct types. In the first they were more or less solitary and in the second they were multiple, diffusely disseminated over the greater part of a limb and in some parts showed a tendency to become confluent, particularly in the old standing parts of the condition. The general character of the pathological process is the same. It presents the appearance of warty growths, which are distinctly friable to the touch, superficially involving the skin and to a slight extent some of the deeper connective tissue and fat underlying the infected area of the skin. In no case was there any suggestion of sinus formation, and no

<sup>1</sup> From the Department of Pathology, South African Institute for Medical Research, Johannesburg.

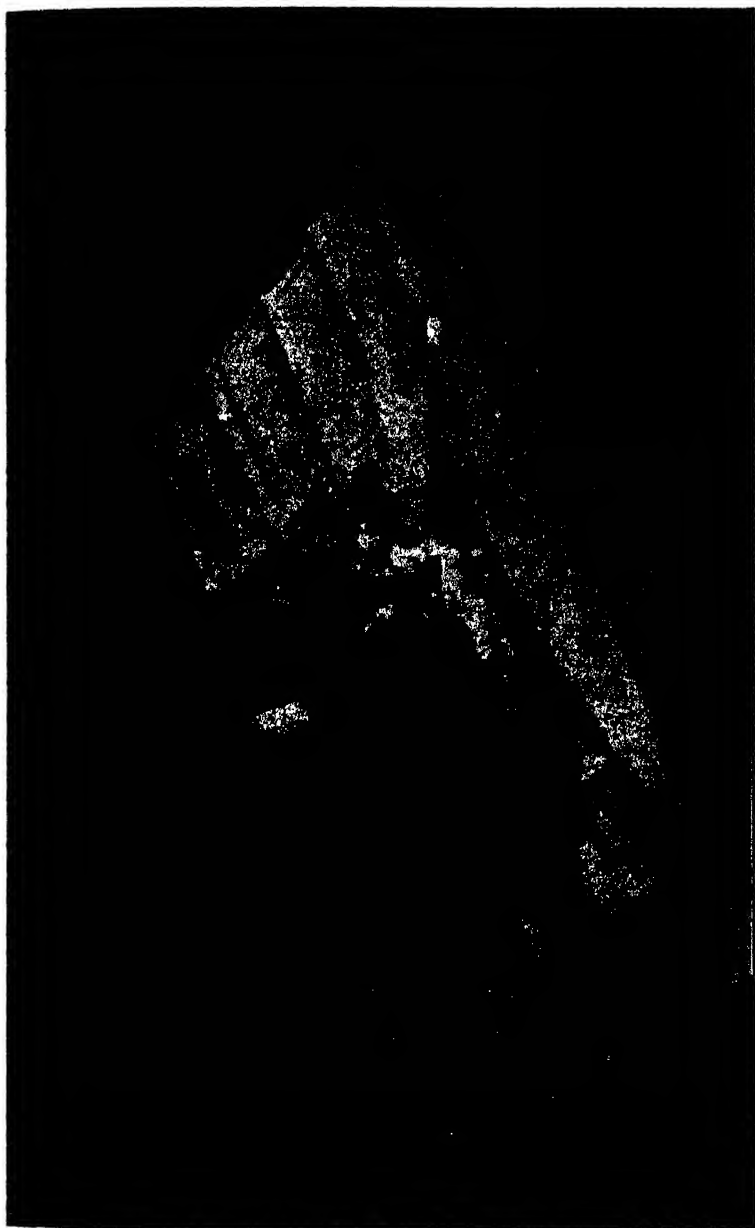


FIG. 1. Chromoblastomycosis.

involvement of deeper structures, such as muscle and bone, was ever observed.

Histologically, the inflammatory condition, which results from the presence of the fungus, is basically a reticulo-endotheliosis. In a section of infected skin and subjacent subcutaneous tissue, there is irregularity and warty thickening of the squamous epithelium with some degree of hyperkeratosis. The rete pegs are hypertrophied and elongated and are often found to extend deeply into the corium. The corium is much thickened by the inflammatory process, the background of which consists of infiltrating plasma cells, small round lymphocyte-like cells, eosinophiles and connective tissue elements. The characteristic part of the inflammation, however, consists of two kinds of follicle formation. These follicles are embedded in the background of non-specific inflammatory tissue. One follicle, which is found more commonly in the very chronic lesions, is composed almost wholly of reticulo-endothelial cells, sometimes with a centrally placed multinucleated giant cell of the Langhans' type. These giant cells may or may not contain one or more brownish colored "sclerotic bodies"—the characteristic tissue form of the fungus. The second type of follicle consists of a central area of neutrophil polynuclear leucocytes surrounded by an outer zone of reticulo-endothelial cells. Sclerotic bodies may also be found in these follicles. The follicles of the very chronic lesions often closely simulate the appearance of tuberculosis, but absence of tubercle bacilli and the presence of sclerotic bodies should eliminate any possibility of confusion with this disease.

The sclerotic body or tissue form of the fungus is quite distinctive. It is rounded, brown or yellowish brown in color and measures, as a rule, 6-10  $\mu$  in diameter. It shows no significant variation in structure, no matter in what type of clinical manifestation of chromoblastomycosis it may be found. This seems to be important when considering the fact that so many varieties of the vegetative form of the fungus have been recovered from chromoblastomycotic lesions in which these bodies have been demonstrated.

From this it will be gathered that the variety of the fungus subsequently to be isolated cannot be predicted either by the char-

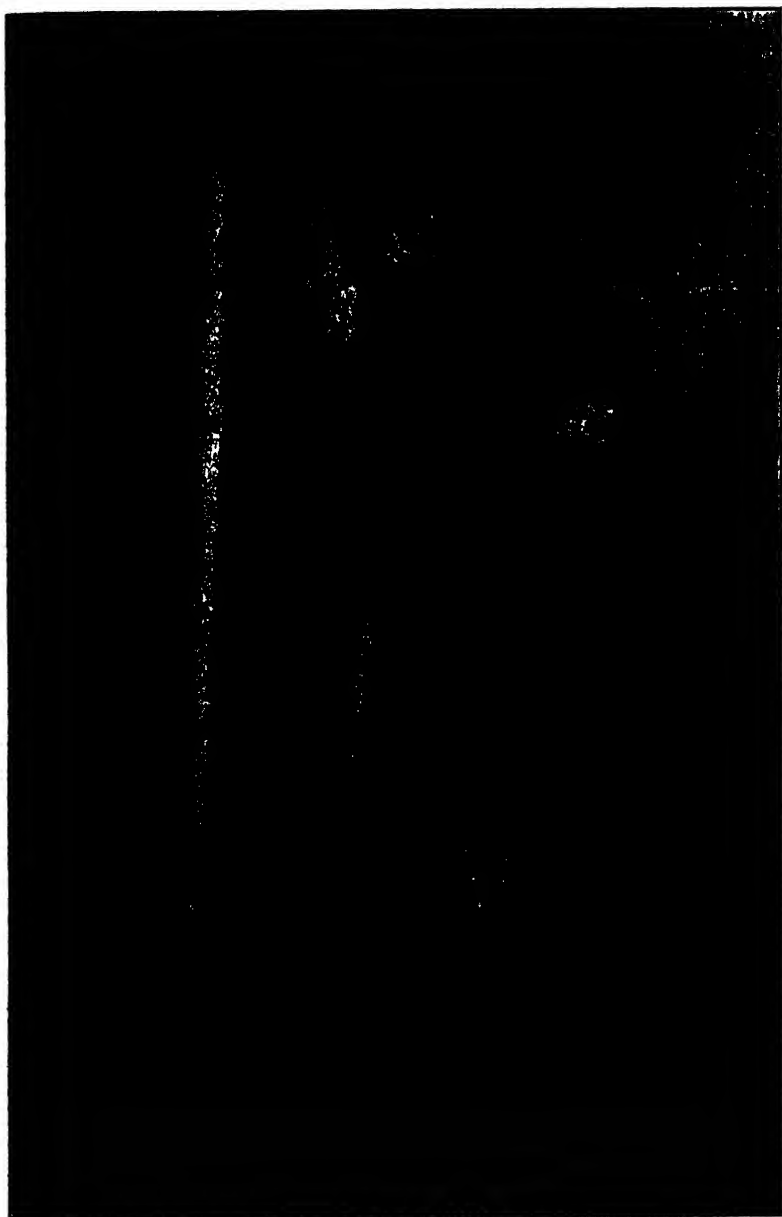


FIG. 2. Chromoblastomycosis.

acter of the tissue change or by the appearance of the sclerotic bodies.

#### MYCOLOGY

As fungi, recovered from different cases of chromoblastomycosis, may show respectively great variation in their morphology, it is convenient at this point briefly to discuss the classification of the organism.

Among the group of fungi responsible for the lesions of chromoblastomycosis, three methods of sporulation may be found and because only one or sometimes two may be present in a given culture, much confusion in the classification has resulted.

A. L. Carrión (2) has suggested the adoption of a classification which would seem to eliminate most of the confusing issues. In this classification he states ". . . In *Fonsecaea Pedrosoi*, the variety *communis*, which possesses the three types of sporulation—*Cladosporium*, *Phialophora* and *Acrotheca*,—appears to be the common origin of all other forms. The varieties *Cladosporioides*, *typicus* and *Phialophorica* show, respectively, a marked predominance of the *Cladosporium*, *Acrotheca* or *Phialophora* sporulations with a corresponding reduction, in each case, of the other two methods of reproduction. In the species *Phialophora verrucosa* and in the *Hormodendrum* isolate from Venezuela . . . , the *Phialophora* and the *Cladosporium*, respectively, have become the exclusive methods of reproduction."

Carrión (2) also suggests the presumptive existence of other parasites sporulating exclusively by the *Acrotheca* method and that the specimen described as *Botrytoides monospora* by Moore and Almeida comes very close to fulfilling this condition.

The fungus described by Simson, Harington and Barnetson (1) as a pathogenic *Hormodendrum* awaiting classification (FIG. 5) was sent to Dr. A. L. Carrión for favor of his opinion. In a personal communication to the author Dr. Carrión expressed the opinion that this organism is a *Hormodendrum* species closely similar to J. A. O'Daly's isolate from the Venezuelan case.

Of the six South African isolates mentioned previously, two described by Simson, Harington and Barnetson (1) and four recent isolates by the writer, three have been classified as examples

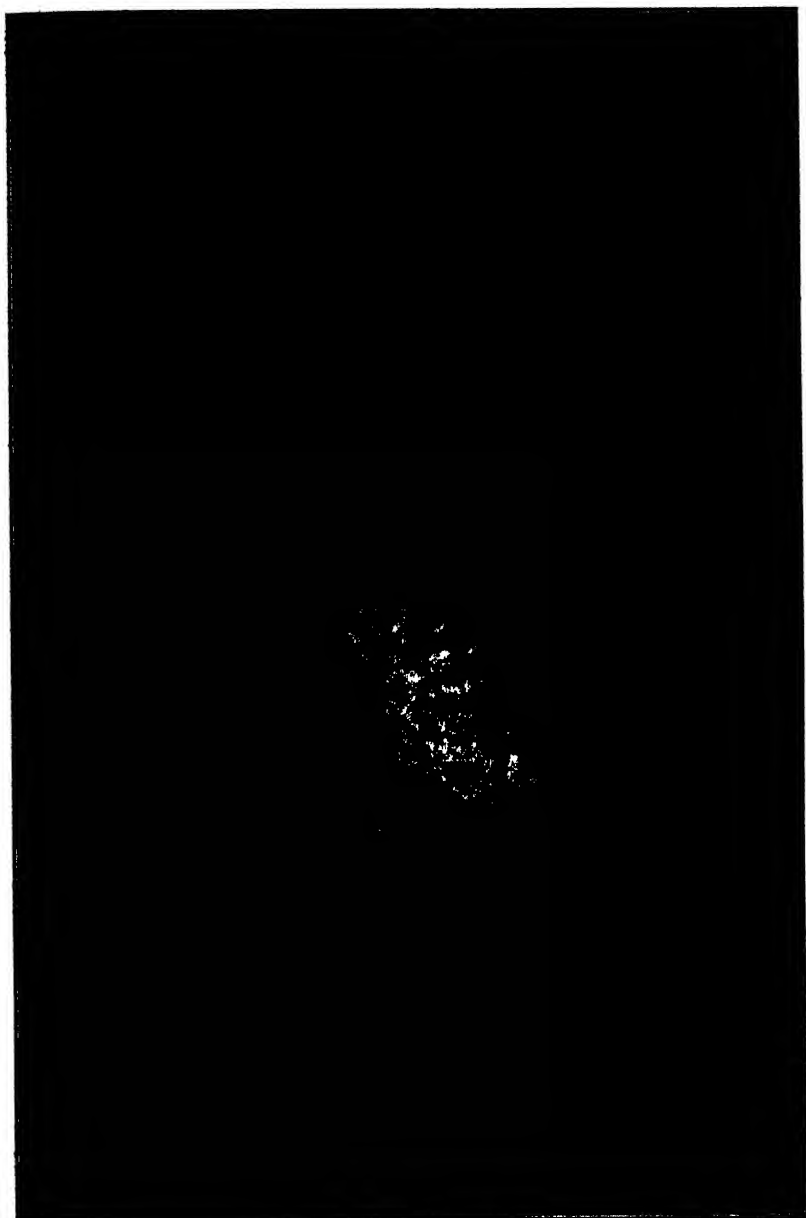


FIG. 3. Chromoblastomycosis.

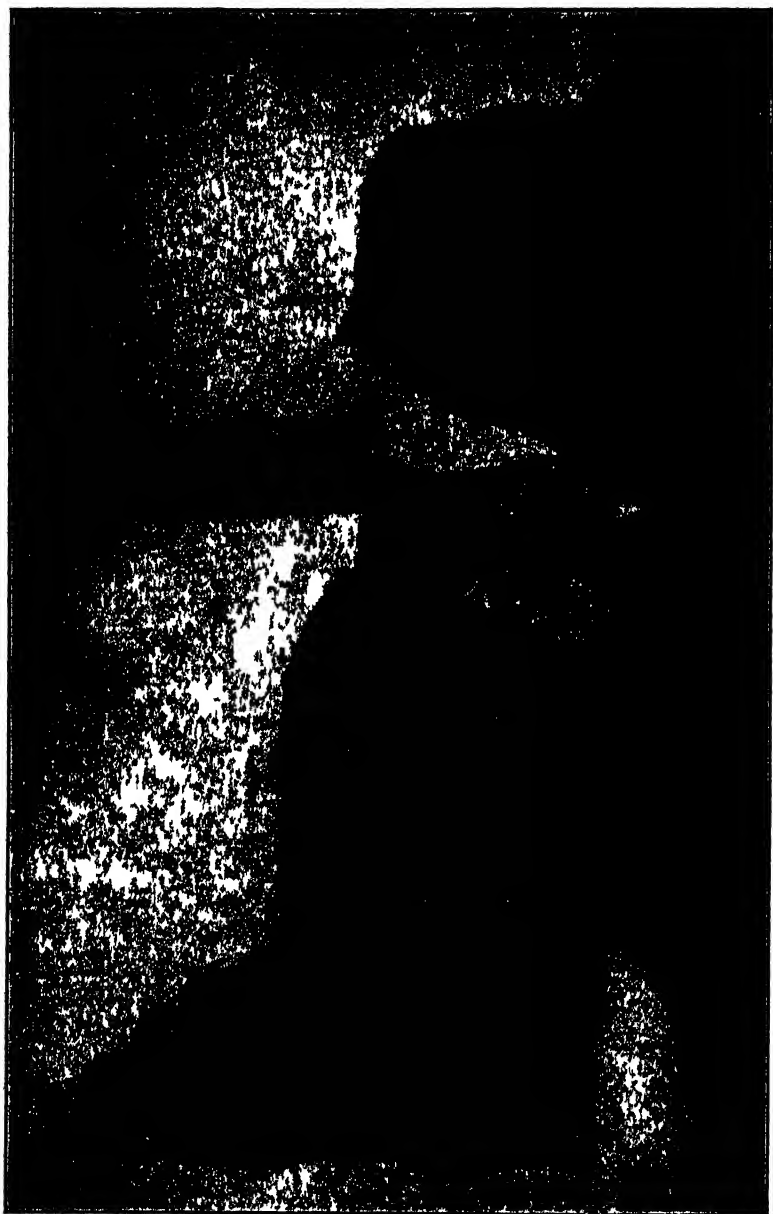


FIG 4 Chromoblastomycosis

of *Fonsecaea Pedrosoi typicus* and three as *Hormodendrum* species similar to J. A. O'Daly's case.

In the three isolates diagnosed as *Fonsecaea Pedrosoi typicus* the *Acrotheca* method of sporulation predominates, the *Cladosporium* form of reproduction is rare and no *Phialophora* cups have as yet been found.

In the second group of three cases the cultural characters of the fungi show no variation and only one method of sporulation is represented, namely the *Cladosporium* or *Hormodendrum* form of reproduction. Cultures have been made on many varieties of medium but no other form of sporulation has been induced. In each instance these three fungi show colonies consisting of a long septate branching mycelium with hyphae averaging  $2.5\ \mu$  in diameter and possessing terminal and laterally branching conidiophores. The conidia are produced acrogenously in arborescent chains on these terminal and lateral conidiophores. The color of the mycelium is light olive green shading to deeper olive green in the conidiophores. The microscopic appearance is shown respectively in FIGS. 5, 7 and 9.

Carrión (2) has suggested that as a result of his experience the species of the fungus causing the infection does not have much influence on the clinical picture. Among the South African cases on the other hand there is evidence to suggest that the clinical picture may be altered by the species of fungus.

Two outstandingly different varieties of clinical lesion have been noted among the twelve cases recorded here but as in six of them no organism was isolated the variety of the fungus was not identified. Of the remaining six cases which were examined clinically, and from lesions in each of which the fungus was recovered, three showed two or three solitary widely separated lesions (FIGS. 1, 2 and 3). FIGS. 2 and 3 illustrate cases in which there was a cauliflower-like growth in the region of the ankle and a smaller secondary growth situated just below the knee on the same side. In the third case (FIG. 1) a large cauliflower-like growth almost surrounded the ankle and two smaller tumors were present on the upper and posterior aspect of the thigh of the same limb. The organisms isolated from these three cases showed the cultural characteristics of *Fonsecaea Pedrosoi typicus*.





FIG 5. *F. Pedrosoi* var. *Cladosporium*.



FIG. 6. Chromoblastomycosis.

Multiple lesions were characteristic of the condition in the second group of three cases (FIGS. 4, 6 and 8). They affected the greater part of one lower limb and the fungus recovered from each of these showed the cultural characters of *Fonsecaea Pedrosoi* var. *Cladosporium* (FIGS. 5, 7 and 9). This series of cases is admittedly small but the finding of a specific organism in a specific type of lesion is consistent and therefore suggestive.

It might be objected that the diffuse lesions are a late manifestation of the disease and that the solitary lesions if given sufficient time might progress to such an extent that the limb becomes diffusely involved. This, however, would seem to be unlikely since some solitary lesions have a long history. The case illustrated in FIG. 1 for instance gives a history of having started ten to fifteen years before the date of isolation of the causal fungus and the diagnosis of the disease. The spread of the condition from the primary site of the infection appears to differ in the two types of clinical lesion. In the solitary type it is probably the result of inoculation by scratching because of the distance between primary and secondary growths. In the diffuse type, on the other hand, spread appears to be by superficial lymphatics.

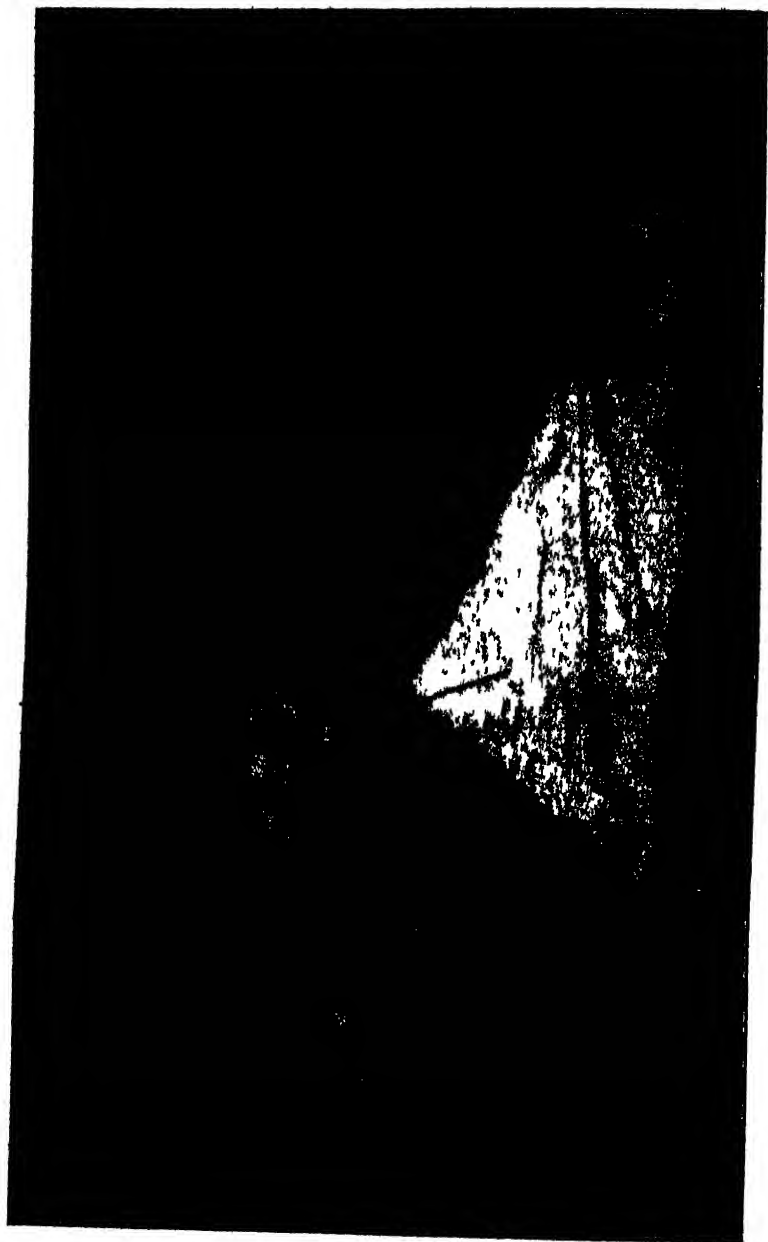
#### TREATMENT

So far no drug has been found which will cure the disease. The only methods of treatment attended with success are surgical removal, either locally or by amputation of the part, and electrotherapy. The type of lesion, therefore, whether local or diffuse is of great importance in the treatment. Some of the solitary lesions in our series of cases have been treated successfully by local excision and two of the cases with diffuse lesions have been treated by amputation. One was followed by recurrence of the disease in the stump and on the hand of the opposite side. The fate of the second case is not known.

Treatment by freezing of the part was suggested as a means of curing the condition in one of this series of cases—a European male with multiple lesions covering the leg and lower half of the thigh of the right limb (FIG. 8). Before attempting the treatment on the living subject, however, it was thought advisable to carry



FIG. 7. *F. Pedrosoi* var. *Cladosporium*.

Fig. 8. *Chromohialastomycosis*

out an *in vitro* experiment. For this purpose a large papillomatous mass was removed by excision. This piece of tissue was divided into six more or less equal and representative parts and each part was given an identification letter *a* to *f*. Specimen (*a*) was prepared for section and on examination showed the typical histological picture of chromoblastomycosis and in the granulation tissue the characteristic sclerotic bodies were identified.

Specimen marked (*b*) was used as a control and without being treated by freezing was ground up very finely in a mortar and plated out in a Petri dish on Sabouraud's glucose agar medium.

Specimens (*c*), (*d*), (*e*), and (*f*) were transferred to fresh sterile bottles which were placed in a refrigerator and kept at a constant temperature of 0° Centigrade.

Specimen (*c*) was finely ground up in a mortar under sterile conditions and plated out on Sabouraud's medium after a period of freezing for 21 hours.

Specimen (*d*) was prepared in the same manner and plated out after a period of freezing for 72 hours, specimen (*e*) after freezing for 168 hours and specimen (*f*) after freezing for 336 hours. All plates of the series after inoculation were incubated at room temperature (about 22° C.).

Numerous colonies of a pathogenic fungus identified microscopically as *Fonsecaea Pedrosoi* var. *Cladosporium* appeared after the fourth day of incubation on each of the plates marked (*b*), (*c*), and (*d*), representing growth on the control plate and on plates sown with tissue forms of the fungus which had been frozen respectively for 21 hours and 72 hours. FIG. 10 is a photograph of plate (*d*) and shows the appearance of the dark colonies of the fungus three weeks after planting. The colonies were still viable after two months' incubation at room temperature.

Plates (*e*) and (*f*), cultures of organisms frozen respectively for 7 and 14 days, showed viable colonies of the fungus but much fewer in number than appeared on plates (*b*), (*c*), and (*d*). Later, for some unknown reason, although there was at first undoubted evidence of viability of some of the sclerotic bodies, all colonies, including some which had reached a stage of sporulation, died out. It was thought that the death of the fungus on these plates might have been due to some autolytic change in the frozen granu-



FIG. 9. *F. Pedrosoi* var. *Cladosporium*.

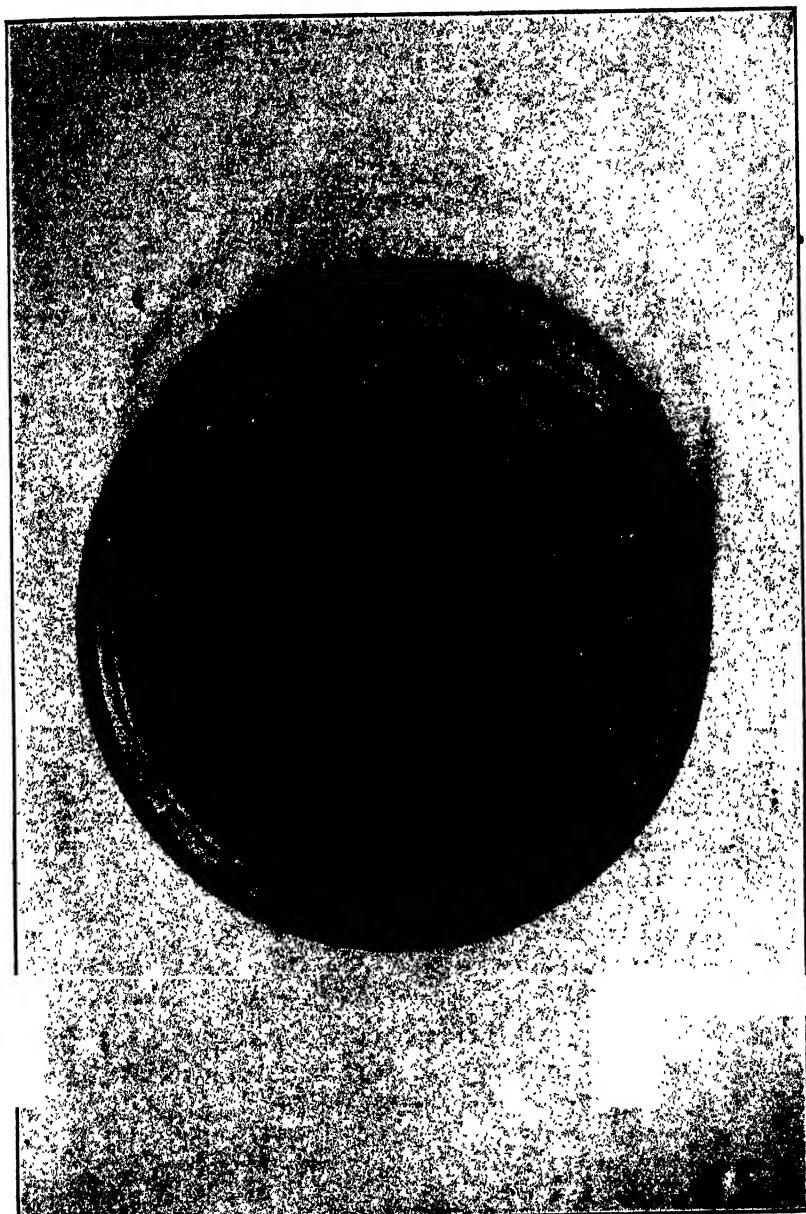


FIG. 10. *F. Pedrosoi* var. *Cladosporium*.



lation tissue with which the sclerotic bodies were mixed at the time of spreading the plates. Evidence that the colonies were viable for a time on these plates was provided by growth of hyphae and definite signs of sporulation. It was concluded from this experiment that the tissue form of the fungus from this case of chromoblastomycosis continues to be viable after being kept at a constant temperature of 0° C. for as long as 14 days.

Further, it may be deduced from the experiment that reducing the temperature of a living affected tissue to a safe point (10° C. or slightly less) is unlikely to prove of value in the treatment of chromoblastomycosis.

#### SUMMARY

The purpose of this report is to place on record the isolation of six fungi from cases of chromoblastomycosis occurring in South Africa, three of which have been identified as a rare species *Fonsecaea Pedrosoi* var. *Cladosporium*.

It has been suggested in addition that there is evidence to show that in South Africa two varieties of *Fonsecaea* cause respectively two different types of clinical lesion.

Finally an experiment is recorded which shows that the tissue form of the organism remains viable after being kept at freezing point for 14 days which provides evidence to show that treatment of chromoblastomycotic lesions by lowering the temperature to a safe point is not likely to be effective.

#### ACKNOWLEDGMENTS

I wish to record my thanks to Dr. A. I. Girdwood of the W. N. L. A. Hospital, Johannesburg, to Dr. J. Daneel of the Rietfontein Hospital and to Dr. J. I. H. Frootko of Krugersdorp Hospital for allowing me access to their cases of chromoblastomycosis and to Mr. F. A. Brandt for the photographic illustrations.

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## DESCRIPTION OF FIGURES

FIG. 1. African female adult. Large solitary cauliflower growth almost surrounding left ankle. Contracted 10-15 years prior to examination and isolation of fungus. Causal organism *Fonsecaea Pedrosoi typicus*.

FIG. 2. African male adult. Warty friable growth just above lateral malleolus, left leg. Smaller growth on same leg behind head of fibula. Duration not ascertained. Fungus isolated *Fonsecaea Pedrosoi typicus*.

FIG. 3. African male adult. Warty friable growth situated above left malleolus, left leg. Secondary growth situated just below tuberosity of tibia. Duration not known. Fungus isolated *Fonsecaea Pedrosoi typicus*.

FIG. 4. African male adult. Warty growths disseminated over greater part of right leg. Duration probably many years. Leg amputated. Fungus isolated *Fonsecaea Pedrosoi* var. *Cladosporium*.

FIG. 5. Microscopic appearance of fungus isolated from lesions shown in figure 4. Septate hypha bearing exclusively *Cladosporium* or *Hormodendrum* conidiophores.

FIG. 6. African male adult. Disseminated warty growths covering the leg and part of the thigh of right limb. Duration of condition not known. Fungus isolated *Fonsecaea Pedrosoi* var. *Cladosporium*.

FIG. 7. Microscopic appearance of fungus isolated from lesions shown in figure 6. Septate hyphae bearing exclusively *Cladosporium* conidiophores.

FIG. 8. European male adult (Mongol). Diffuse warty growths covering leg and part of thigh of right limb. In the middle third of leg partial spontaneous healing has occurred. Duration probably more than 15 years. Fungus isolated *Fonsecaea Pedrosoi* var. *Cladosporium*.

FIG. 9. Microscopic appearance of fungus isolated from lesions shown in figure 8. Septate hyphae bearing exclusively *Cladosporium* conidiophores.

FIG. 10. Plate showing black colonies of *Fonsecaea Pedrosoi* var. *Cladosporium*. Three weeks growth after cultivation of tissue forms of the fungus following freezing for 72 hours.

# ELSINOË PIRI IN FRANCE AND SPAIN IN THE LIGHT OF QUARANTINE INTERCEPTIONS

ANNA E. JENKINS

(WITH ONE FIGURE)

Fresh apple fruits infected by *Elsinoë piri* have previously been intercepted in transit from Ireland, Italy, Switzerland, and Hungary, by port inspectors of the U. S. Bureau of Entomology and Plant Quarantine (3: 689). Two additional interceptions of this pathogen on apple fruit, also in transit from Europe, are here recorded.

The more recent of the two is from Spain, and was taken at Galveston, Texas, by R. L. Trigg, on October 16, 1945. This consists of two apples on which are a limited number of spots caused by *Elsinoë piri* (FIG. 1, A and B). These are large as compared, for example, with the numerous spots on an apple fruit previously intercepted from Ireland (3, FIG. 1). On the apples from Spain the spots are "vinaceous buff" (6) at the center surrounded by "dark mineral red," outside of which is a more or less indefinite zone of "terra cotta." The healthy apple skin in the region of the spotting is "citron green." The particular spot shown in FIG. 1, B, a, closely resembles that on the "Ortly" apple variety from Washington State, illustrated elsewhere (4, FIG. 1, G) at a magnification of  $3\frac{1}{2}$  diameters, and here shown in still greater detail (FIG. 1, C). The dark markings on the spot (FIG. 1, C, a) are the conidial stage protruding through the ruptured epidermis.

The first and only available record of *Elsinoë piri* from Spain is furnished by *Melanobasidium mali* Maubl. (5), which we have shown to be a synonym of *Elsinoë piri* (3: 692 and 696).

The two fresh apples from Spain may well be a variety that originated in that country. Except for their slight blush, these fragrant apples resemble the variety "Reinette de Zaccalmaglio," as illustrated in Switzerland by Zschoppe (11). In this natural color reproduction, one of the whole fruits shows typical *Elsinoë* infection. The apples from Spain, as well as the "Reinette de Zaccala-

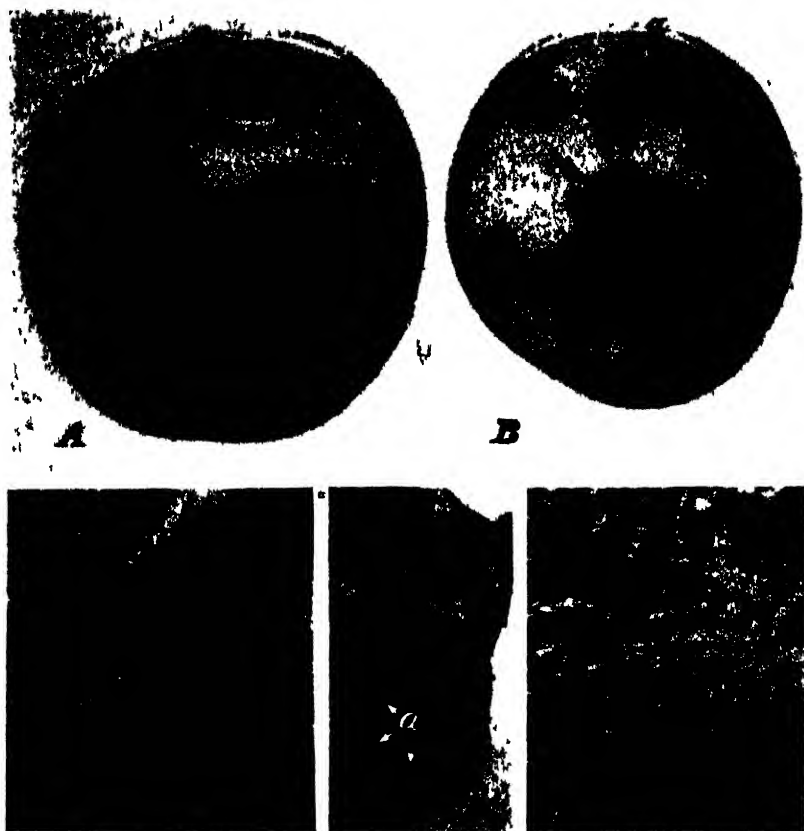


FIG. 1. A and B. *Elsinoe piri* on apples intercepted in transit from Spain.  $\times 1$ . C. Spot on "Ortly" variety, Bay Center, state of Washington, U. S. A., resembling closely the spot B, a, when similarly magnified, a, conidial stage.  $\times 12$ . D. Parts of the interception from France, showing the spots on the dried apple rind.  $\times 1$ . E. Same as D, a,  $\times 3\frac{1}{2}$ . Photographs by R. L. Taylor.

maglio," are a different variety from the "Reneta" (sic) (Reineta) from Portugal on which *E. piri* was previously identified (3: 698). This is a large flattened-globose red-striped, dessert apple, of which the full varietal name is "Reinette Espriega"; it is widely grown in Portugal and commonly shows the spotting herein described.<sup>1</sup>

<sup>1</sup> This information was furnished by F. M. Villhena, Chief of Services, Department of Agriculture, Lisbon, Portugal, on the occasion of his recent visit to the Plant Industry Station.

The other interception to be reported here is from France and was taken at the port of New York on January 6, 1945. In this case the fungus was identified by W. S. Fields, then referred to the writer for verification. The specimen received consisted of large pieces of dried apple peel on which were numerous spots (FIG. 1, D). On those larger and more mature, the imperfect stage was present in abundance, forming conspicuous light colored pustules (FIG. 1, E). These were covered with a thick, dry crust of hyaline conidia.

At the time that the combination *Elsinoë piri* (Woronich.) Jenkins (3: 696) was made, *Hadrotrichum pirinum* (Pegl.) Sacc. (7), as well as *Melanobasidium mali*, was shown to be a synonym. Saccardo's combination was made in reporting Hariot No. 12 on pear leaves from Paris (department of Seine-et-Oise), France. Arnaud and Arnaud's (1, v. 2: 1059) *Melanobasidium* (?), abundant on pear leaves at Chevreuse, department of Seine-et-Oise, during the rainy seasons of 1930 and 1931, is unquestionably *E. piri*, as apparently is an apple fruit-spot fungus described much earlier by Griffon and Maublanc (2: 79-80, FIGS. 3 and 4). For the conidial stage of *E. piri* I have now made (4) the combination *Sphaceloma pirinum* from *Gloeosporium pirinum* Pegl.

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## A NEW SPECIES OF STAGONOSPORA ON AMBROSIA<sup>1</sup>

D. B. O. SAVILE<sup>2</sup>

The writer recently had occasion to examine the material in the herbarium of the Division of Botany and Plant Pathology of Seym. & Earle Econ. Fungi 294b. This specimen is labelled "*Cercospora racemosa* Ell. & Martin var. *Ambrosiae* Seym. & Earle and *Entyloma Compositarum* Farl. on *Ambrosia trifida*." The packet contains three pieces of leaf; one bears the red-brown fructifications of the *Cercospora*, which incidentally is not typical of this genus since the spores are largely catenulate; the other two bear the *Entyloma*. The *Entyloma* is a typical example of *E. Compositarum*, but examination of the upper surface of the lesions shows abundant pycnidia of a *Stagonospora*. This fungus appears to be unnamed, and, because of its occurrence in exsiccated material, it seems advisable that it should now be described, despite the fact that only a single specimen has been seen.

***Stagonospora Ambrosiae* Savile sp. nov.** Pycnidia epiphylla 69–107  $\mu$  lata  $\times$  62–86  $\mu$  alta, rotunda, leviter complanata, ostiolis plerumque ellipticis 11–21  $\times$  8–15  $\mu$  cingulis nigris, pycnidia raro omnino nigra sed plerumque infra pallida, astromatica; conidia hyalina, 10–33  $\times$  (2.2) 2.5–3.5  $\mu$ , 1–6 plerumque 3–4-septata, recta vel leniter curvata, supra fastigata ad apices rotundatos, inferne truncata subtruncatave.

On lesions of *Entyloma Compositarum* on *Ambrosia trifida*, Valley City, North Dakota, coll. A. B. Seymour; in Seym. & Earle Econ. Fungi 294b in the Mycological Herbarium of the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

The conidia illustrated in FIG. 1 have been selected to show the range in size and septation rather than the relative abundance of spores of different forms. In some pycnidia the spores are uni-

<sup>1</sup> Contribution No. 847 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

<sup>2</sup> Junior Plant Pathologist.

to quadri-, generally tri-septate; in others the septa are frequently four and occasionally five or six.

From the abundance of the fungus in the Ottawa material, it appears probable that it will prove to be present in at least some other packets of this collection.

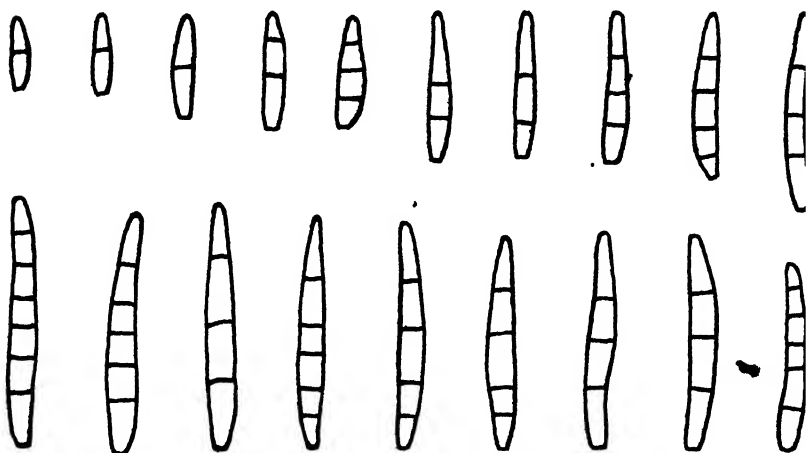


FIG. 1. Conidia of *Stagonospora Ambrosiae*  $\times 1000$ .

The writer has been unable to find a reference to any *Stagonospora*, or any other genus on *Ambrosia* to which this fungus might reasonably be assigned. He wishes to thank Mr. John A. Stevenson, Bureau of Plant Industry Station, Beltsville, Md., for searching the records of the Bureau for such a fungus.

In this material no pycnidia were seen on the normal leaf tissue, but it is possible that the healthy leaves are occasionally attacked. As will be described in a forthcoming study of *Entyloma* on the Compositae, two specimens have been seen in which *Septoria Lepachydis* is associated with *Entyloma* spp. on *Lepachys columnaris*. In these specimens pycnidia are occasionally found on the normal leaf tissue, and it may be supposed that the *Septoria* is a weak parasite that is well-adapted to attacking tissue already weakened by the smut. The similar habit of *Stagonospora Ambrosiae* suggests that it may have a corresponding rôle.

# CONTROL OF CULTURE MITES BY CIGARETTE PAPER BARRIERS

WILLIAM C. SNYDER AND H. N. HANSEN

(WITH 2 FIGURES)

Workers in mycological and phytopathological laboratories are, unhappily, only too familiar with the several species of mycophagous mites that invade their test tubes and cause serious inconveniences by destroying pure cultures or by contaminating them with other fungi, actinomycetes or bacteria. Some eight years ago when we began a monographic study of the genus *Fusarium* (13, 14) which involved handling and keeping for observation thousands of cultures for periods of several months, we soon realized that the first requirement for effective and dependable work would be to devise some easily applied method by which our cultures could be kept entirely free of mites. In this paper is described a method of mite control which has been in constant use for more than six years and proved to be entirely satisfactory.

## SOURCES OF INFESTATION

The species of mites encountered in the present study were all members of the family *Thyroglyphidae* which inhabit various kinds of stored food products, the roots, bulbs, rhizomes etc. of living plants, particularly those with fungous lesions, and also aerial parts of plants, where these support fungi or lichens. All such materials which are brought into most laboratories almost daily probably constitute the main source of infestation of fungous cultures. Another, and not uncommon, source of infestation is the exchange of cultures between laboratories. In our study of the genus *Fusarium* we found that about twenty five percent of the cultures received from various parts of the world were infested with mites. A third source of infestation is the common house fly, and perhaps other winged insects, which carry these mites in their migratorial (hypopial stage) (1, 5). We have repeatedly found both the hypopial and the adult stages on house flies.



## ELIMINATION OF MITES FROM INFESTED CULTURES

Sanitary measures are undoubtedly salutary everywhere and particularly so in biological laboratories, i.e. material brought in should be disposed of quickly and not be allowed to lie around until it dries out sufficiently to compel the fauna on it to seek fields more compatible with their requirements for moisture and food. The statement of Thom (15:49) however seems to be much to the point: "Entire elimination of mites by sanitary measures is possible but not usually attained."

Fumigation, as a means of ridding cultures of mites, has perhaps received most attention (4, 7, 8, 9, 10, 11) but has nevertheless not solved the problem. The mites involved are without tracheae and therefore are not very susceptible to gases. For this reason gases to be effective must be of such concentration that they usually prove to be toxic to the fungi and frequently noxious to the operators applying them. Of the various substances tested pyridine (7) appears to have been the most suitable, apparently being lethal to mites in concentrations that are only slightly toxic to the fungi tested (*Penicillium* and *Aspergillus*). Pyridine has been used on many other fungi with varying success. More recently advantages have been claimed for p-dichlor-benzene (4, 9) as a fumigant.

Mites may be eliminated with greatest safety by subculturing to water agar or acid nutrient agars in petri dishes to discourage development of bacteria which are frequently found in mite infested cultures. Later transfers are made from the margins of the plate cultures or from hyphal tips. A still better method is to make several single-spore cultures from each infested tube, as this insures purity of the culture, that is, freedom from contaminating micro-organisms as well as mites. Elimination of mites from infested cultures however is only a minor step in the control of these pests. The real control consists in keeping them out. The problem has been covered well by Smith (12: 211-16).

## PROTECTION OF CULTURES BY BARRIERS

The water barrier for the exclusion of mites has probably been in use for the longest period of time. Its application has been recommended by Barnes (2). This method consists simply in placing

wire baskets of cultures on a pedestal in a pan of water. Such a barrier is quite effective against pedestrian mites but not at all against those possibly carried on the hands and clothing of the worker (15), nor against those carried by flies and other winged insects (12). Also, if a single tube happens to be infested all cultures within the barrier will soon be invaded. This is a weakness characteristic of group protection as against individual protection, which latter, if successful, automatically protects the group.

Chemical barriers have also been advocated from time to time and are still in use. The chemical barrier has the merit of protecting each individual tube against infestation. It consists in treating the cotton plugs or the insides of the rims of test tubes with a chemical that is toxic to the mites. That these chemicals are also toxic to fungi is indicated in the fact that those who advocate their use (3, 10, 11, 15) also stipulate that the chemicals should not be applied until the culture is fully grown or nearly so. Aside from the serious disadvantage of the deleterious effect on fungi of these chemicals their application is somewhat tedious.

Tanglefoot barriers were developed and used by us in an attempt to avoid or eliminate the toxic effect of the chemicals on the fungi (*Fusaria*) with which we were working. The mechanism consists of small brass wire clasps for holding and supporting the tubes. The clasps are soldered onto screws which are screwed into strips of plywood board to within about 3 mm. of the base of the clasp. The exposed 3 mm. length of the screw is then covered with tanglefoot which constitutes the barrier. The strips are then fastened in drawers as shown in figure 1, C. This method has an advantage over the water barrier in that it gives individual protection rather than group protection against pedestrian mites, but, as with the water barrier, it does not protect against mites carried on hands and clothing of workers nor against those which are carried by winged insects.

The cigarette paper barrier across the mouth of the test tube was devised and developed in our laboratory more than six years ago (6). It has been used constantly since then and has given unqualified satisfaction. The method is based on the positive exclusion of the mites from each test tube culture by mechanical means. The materials to be used are shown in figure 2. They

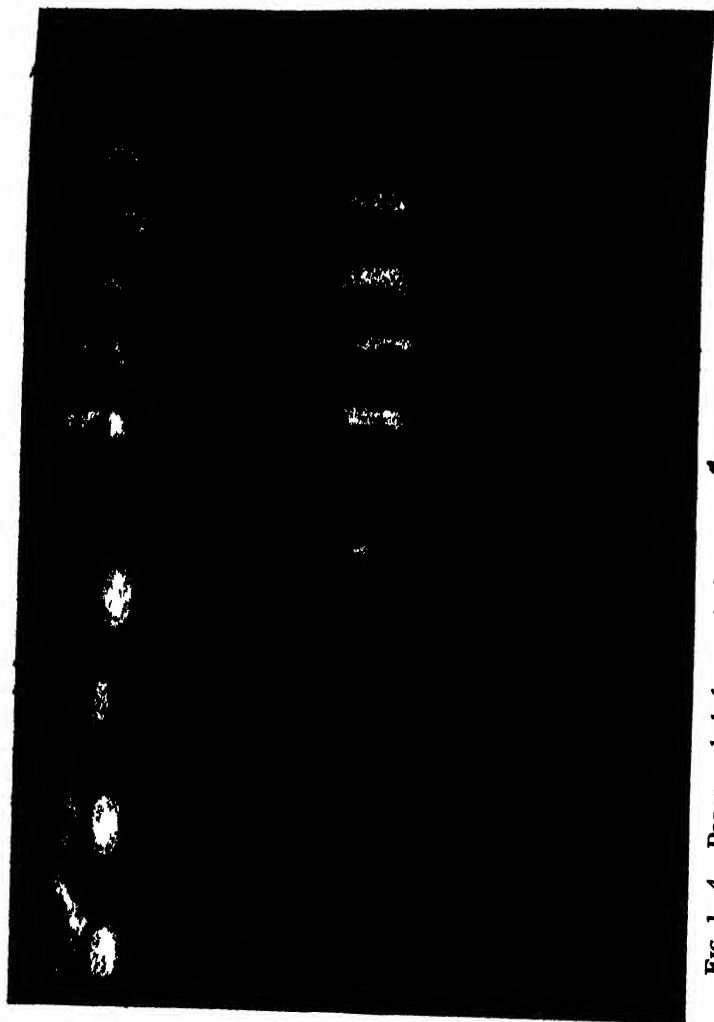


FIG. 1. *A*. Paper seals before and after burning. *B*. The effect on fungal growth of various capping materials. From left to right: Parafilm, Celloseal, Fingerstall, Cellophane and Cigarette paper. *C*. Illustrates tanglefoot barriers. Arrow points

consist of: (a) 20 per cent gelatin in water to which has been added 2 per cent  $\text{CuSO}_4$  to prevent fungal and bacterial growth, (b) a book of cigarette papers—preferably the L. L. F. brand which is also known as Riz La Croix, and (c) a heavy blotter such as is commonly employed in a plant press. About 25 cc. of the melted gelatin and  $\text{CuSO}_4$  mixture are poured into a petri dish and allowed to solidify. The cigarette papers are taken from their cover, the small dab of glue that holds the sheets together is trimmed off and the bundle of sheets is cut in half. The cut papers are placed in a petri dish and may be sterilized in the dry oven. This treatment with dry heat tends to make the papers separate more easily and is necessary should the cotton plug be discarded at the time of sealing a tube.

After a culture has been made by the usual procedure the cotton plug is pushed down inside the tube well below the rim which is then flamed. The tube is held upside down and the flamed rim is pressed gently with a rotary motion against the surface of the solidified gelatin until it is coated with a thin film of the melted gelatin. Then the gelatin-coated rim is placed against the cigarette papers in the petri dish so that the top sheet adheres to the rim and is thus neatly picked up. It is made to adhere tightly to the rim by pressing it firmly against the resilient surface of the blotter. The tube is now placed upright in a rack with other tubes similarly prepared and so arranged that the corners of the projecting pieces of paper touch each other as shown in figure 1, A. When ignited at a single point, the projecting paper on all the tubes will burn off and leave neat, circular paper seals that effectively keep out all mites, spores and other contaminants and which also maintain the cotton plugs free from accumulations of dust.

When sub-cultures are to be made the seal is easily burned off by flaming, and after the transfer is completed the tube may be sealed again.

For cultures in liquid media the rim is flamed and the gelatin plate inverted and the gelatin surface pressed against the hot rim of the tube or flask, after which the cigarette paper is picked up by forceps and placed on the gelatin coated rim.

This cigarette paper barrier is so efficient that cotton plugs need

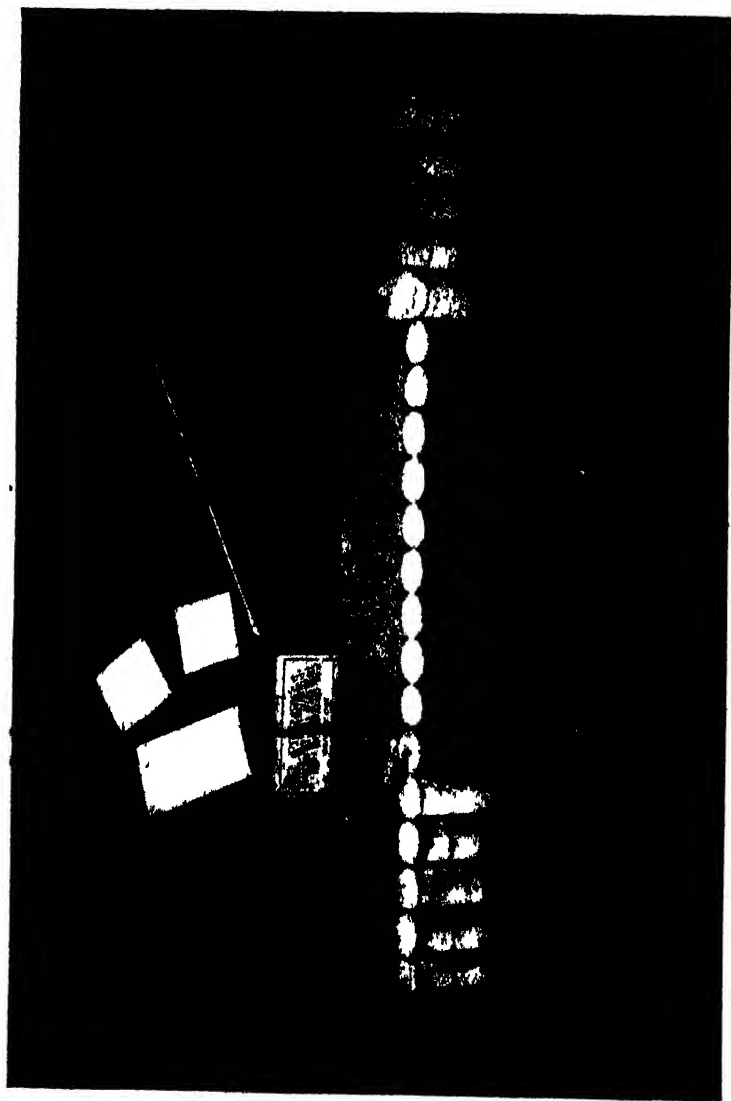


FIG. 2. Materials required for capping with cigarette paper. Also uncapped tubes, tubes capped  
" without plugs and tubes capped with plugs shoved below the rims

only be used to keep the medium sterile until it is seeded (FIG. 2). We, however, prefer the double insurance of both paper and plug.

We have tested several brands of cigarette papers, many other kinds of paper, several grades of cellophane and other materials. All cellophanes and treated papers such as waxed papers greatly depressed growth of the fungi (FIG 1, B). Of the various papers tried only a certain type of white cigarette paper was found satisfactory, such as is represented by the L. L. F. (Riz La Croix), Tip Top, QCB, and Black Sea brands. Of these the L. L. F. paper was best because it leaves the least ash when burned. Other papers tested failed to make a perfect seal because of unsuitable weight or porosity, or were undesirable because they burned with an excessive or undesirable residue.

This new method of mite control has a number of advantages over older methods. The principal one is that it really "works"; there are no fumes toxic to the fungi and annoying to the operator; the materials are readily available, inexpensive, and easily applied.

#### SUMMARY

A method to exclude mites and other contaminants from test tube cultures is described. It consists in covering the mouths of the tubes with cigarette paper which is applied by pressing the flamed rim of the tube against solidified gelatin (20 per cent gelatin in a 2 per cent solution of  $\text{CuSO}_4$ ) and then against the cigarette paper. Excess paper is removed by burning.

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# ELSINOË DISCOVERED ON SESBANIA AND CINNAMOMUM IN THE UNITED STATES

DONALD P. LIMBER, FLORA G. POLLACK, AND ANNA E. JENKINS

(WITH 3 FIGURES)

Examination of plant-disease specimens collected by inspectors of the Bureau of Entomology and Plant Quarantine during the insect and plant disease survey conducted in the general vicinity of ports of entry (1943-1945), revealed the existence of two species of *Elsinoë* Racib. (5), both undescribed. As noted elsewhere (4) one of these two pathogenic species, discovered in South Carolina, produces lesions on aerial growth of *Sesbania exaltata*, sometimes used as a green manure crop (1: 681); the other, found in Mississippi, produces a leaf spot and, less often, inconspicuous stem lesions on camphor-tree (*Cinnamomum camphora*), planted in the Southern States as a street tree (1: 178).

The *Elsinoë* on *Sesbania* was identified by Limber, and the one on *Cinnamomum* by Pollack. Following verification of these findings, Jenkins suggested that a joint study leading to the description of the two species be undertaken.

## ELSINOË ON SESBANIA EXALTATA

On *Sesbania*, lesions are most conspicuous on stems, forming raised cankers reaching 2-5 mm. long by 1-3 mm. wide (FIG. 1. A). By confluence lesions may surround the stem more or less completely, causing an appreciable thickening, and extend as much as 10 cm. When young the lesions are smooth and only slightly elevated, but they soon become corky cankers, with the surface variously roughened, fissured, or pitted. They are generally drab in contrast to the normal brown color of the stem. Ascomata appear as dark specks on the surface of the cankers.

Viewed from above, ascomata are circular to elliptical. They are subcuticular to subepidermal, becoming erumpent. In section as-



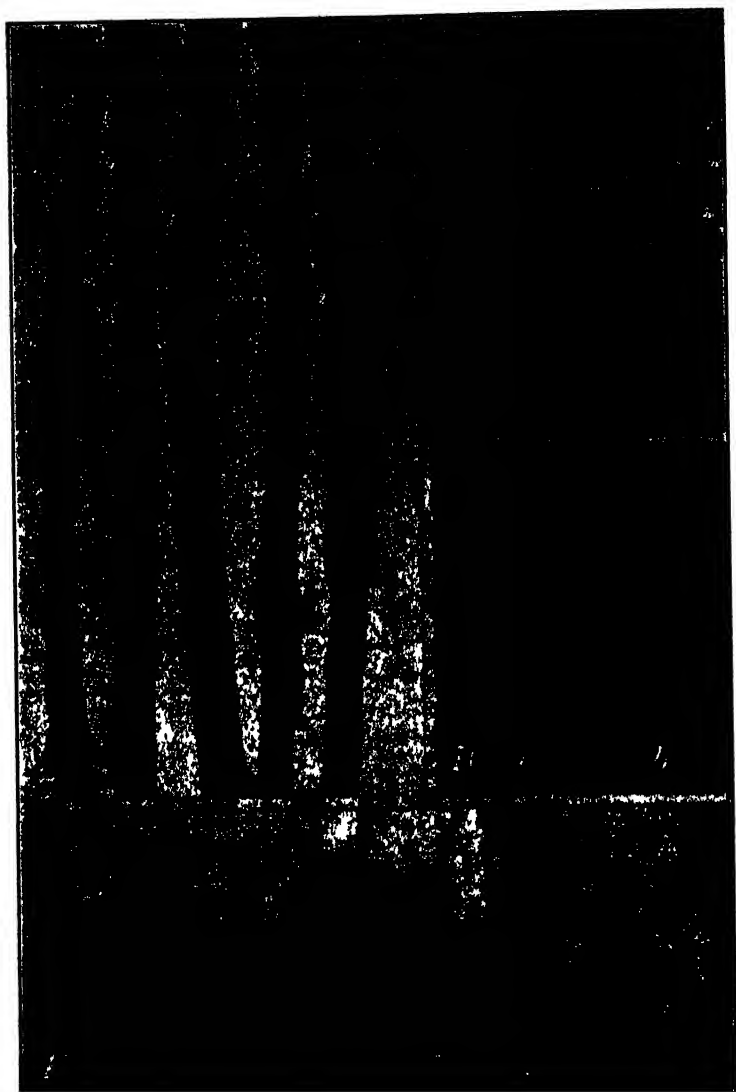


FIG. 1. *Elsinoc* on *Sesbania* and *Cinnamomum*.

comata are ovoid to subglobose ( $46-75 \times 14-40 \mu$ ), often confluent and composed of small, irregularly shaped, pale olivaceous cells with a thin brown epithecium (FIG. 1, B). Asci are eight-spored, few to numerous, often compact in the ascomata, and globose to

ovoid ( $11.5-16 \times 11.5-15 \mu$ ). Ascospores are hyaline, uniseptate to triseptate, usually the latter, constricted at the septa, most strongly at the median septum, and subclavate to oblong with rounded ends. In outline they are often straight on one side and curved on the other ( $10-12 \times 3.5-4.5 \mu$ ) (FIGS. 1, B, *b*, and 3, A).

Acervuli of the *Sphaceloma* stage often occur with the ascomata. They are poorly defined, consist of a dense palisade of pointed conidiophores ( $4-7 \times 1.5-2 \mu$ ), and produce hyaline, oblong-ellipsoid conidia which measure  $3.5-6 \times 1.5-3.5 \mu$  (FIG. 1, C).

The *Elsinoë* was cultured from stem cankers collected at Levy, South Carolina, in October 1944.<sup>1</sup> The fungus grew readily on various media, including Thaxter's<sup>1</sup> (FIG. 1, D, *a*), and potato-dextrose agar (FIG. 1, D, *b*). The month-old cultures on Thaxter's were "cinnamon"<sup>2</sup> to darker, bordered with "cinnamon buff." Corresponding cultures on potato-dextrose agar were "cinnamon brown" bordered by "honey yellow." Conidia and conidiophores were produced in culture (FIG. 3, B, *a* and *b*). As illustrated (FIG. 3, B, *b*), the conidiophores were subulate, subhyaline with granular contents, and constricted where septa were to form.

### *Elsinoë sesbaniae* Limber and Jenkins sp. nov.

Maculae generaliter cinereae, in foliis inconspicuae, plerumque in nervis, in petiolis fructibusque, numerosae, prominentes; cancri in caulibus ex orbicularibus ellipticales, plani ad elevati, suberoso-rugulosi, rimosi,  $2-5 \times 1-3$  mm., conspersi, aggregati, vel coalescentes et caulem usque ad 10 cm. cingentes; ascomata subcuticularia ad subepidermalia, parum exposita, ex ovatis subglobosa, pseudoparenchymatica, dilute olivacea, epithecio tenui fuscoque,  $46-75 \times 14-40 \mu$ , interdum coalescentia; ascosporae hyalinae, 1-3 septatae, saepius triseptatae, ad septum constrictae,  $10-12 \times 3.5-4.5 \mu$ ; acervuli indeterminati, conidiophoris subulatis, subhyalinis,  $4-7 \times 1.5-2 \mu$ , in palum compactum dispositis; conidia oblongo-ellipsoidalibus, continua, hyalina,  $3.5-6 \times 1.5-3.5 \mu$ .

DISTRIBUTION: On stems and pods, inconspicuous on leaves, of *Sesbania exaltata* (Raf.) Cory (Leguminosae), causing scab of *Sesbania*, South Carolina, U. S. A.

<sup>1</sup> For formula of Thaxter's potato agar see Bitancourt and Jenkins, 3, footnote 12.

<sup>2</sup> Names of colors in quotation marks are according to *Color Standards and Color Nomenclature*, by Robert Ridgway (1912).

SPECIMENS EXAMINED:<sup>a</sup> Charleston, South Carolina, October 28, 1943, A. W. Blizzard 565 (Type, in Mycological Collections 74693); Levy, South Carolina, October 5, 1944, L. A. Mayer 1211, and December 14, 1944, L. A. Mayer 1211A.

#### ELSINOË ON CINNAMOMUM CAMPHORA

Lesions have been observed on the leaf blade and petiole, and to a lesser extent on the stem. The first indications of infection on the leaf are small, inconspicuous pale brown spots. These increase in size and may reach 3 mm. in diameter, and on the upper surface become raised, shiny, amber, spots which gradually turn black, and frequently become surrounded by a pale yellow halo (FIG. 2, A and B). The spots occasionally develop white centers, which may be surrounded by raised black ascomata (FIG. 2, E and G). On the lower surface the spots tend to be duller, spreading, and often confluent, and have few ascomata (FIG. 2, H). On both surfaces the lesions become elongate on the veins (FIG. 2, F). Occasionally spots fall out, giving the leaf a shot-hole appearance. Stem lesions, few in number, are dark brown areas that have split open and show white where the epidermis is raised and ruptured.

Sections of diseased areas in the leaf revealed ascomata containing asci and spores. Acervuli were poorly defined and no spores were present. In 1944 attempts were made to isolate the fungus. Cultures gave only rapidly growing associated fungi. Fresh material was received in 1945, and isolation again attempted. This time, after surface sterilization of the leaves, portions about 0.25 of an inch in diameter bearing mature ascomata were cut out and glued to the lid of a Petri dish. The lid was then placed over a plate of corn-meal agar. The plate was allowed to stand for 24 hours and then the lid was rotated about 15 degrees. After 24 hours more had elapsed, the lid was replaced by a sterile one. Within a week it was apparent that ascospores had been shot from both positions of the lid, for typical *Elsinoë* colonies developed on

<sup>a</sup> The specimens cited in this paper have been divided so that part of each is in the Mycological Collections of the U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering, Beltsville, Md., and part in the herbarium of the U. S. Bureau of Entomology and Plant Quarantine, Hoboken, N. J.

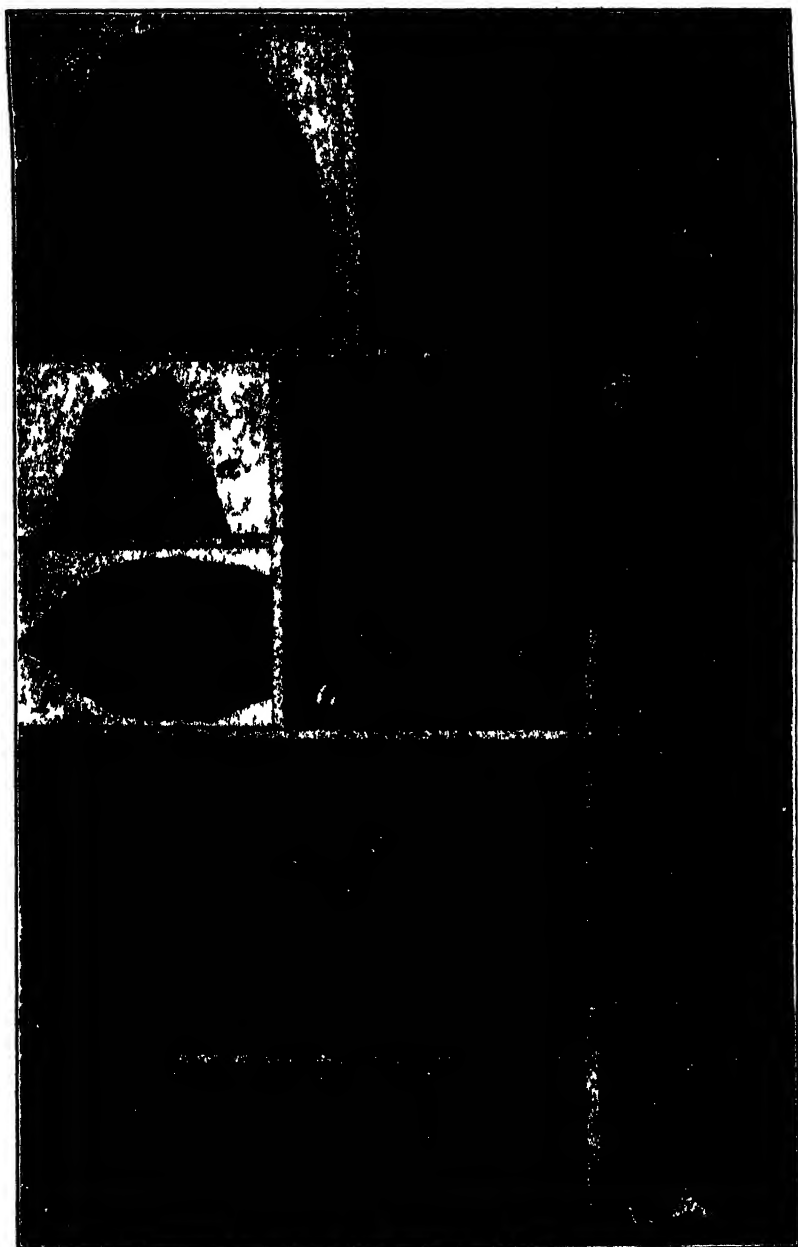


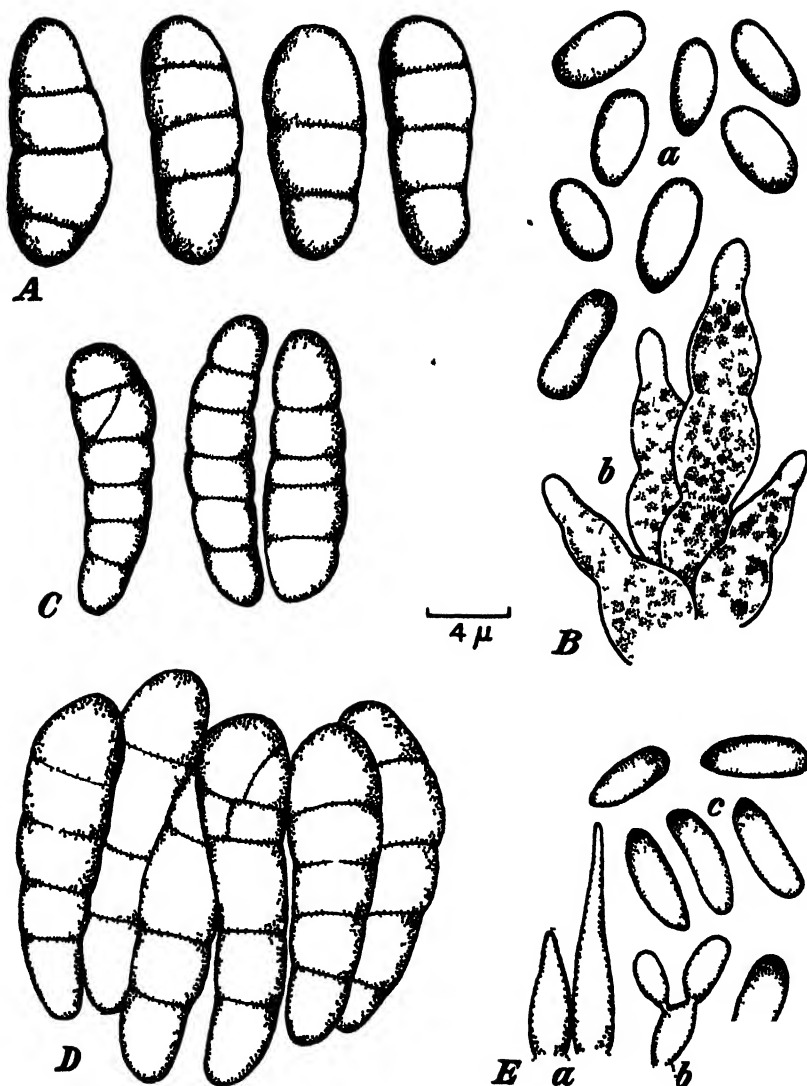
FIG 2 *Elsinoe* on *Sesbania* and *Cinnamomum*

corresponding areas of the agar surface below (FIG. 2, N). These colonies from individual ascospores were used for all subsequent studies.

Seven colonies from single-ascospore isolates were transferred to tubes of Thaxter's agar in April 1945. They grew slowly and, although the growth was thick and velvety, no spores were formed. Color changes of the thalli and in the medium were marked. The medium turned black and the colonies brick red. Several transfers were made to corn-meal agar, and when examined on June 1, 1945, conidia and conidiophores of the *Sphaceloma* stage were found (FIGS. 2, M and 3, E). Since then this stage has been observed in cultures on corn-meal agar ranging in age from one week to two and one-half months. In addition to this development, which was acervular to hyphomycetous, a second stage in the life cycle of this *Elsinoë* developed in cultures from single-ascospore isolates. This is here referred to tentatively as a pycnidial stage. It developed readily on corn-meal, slowly and sparsely on Thaxter's, and not at all on potato-dextrose agar. Transfers were made from vigorous corn-meal agar cultures producing pycnidia to potato-dextrose agar. The subsequent growth on potato-dextrose agar was typical of this fungus on this substratum, but no pycnidia were produced. On corn-meal agar masses of coalesced black pycnidia could be observed with the naked eye (FIG. 2, C. and D). In some corn-meal agar cultures both stages were present at the same time, but the pycnidial form was usually more abundant and conspicuous. At other times only the pycnidial form was present. In Thaxter's agar, for example, no conidia were observed. The pycnidial stage, however, developed on this medium in tubes that were two or more months old.

On all media tried the fungus exhibited pronounced chromogenic capacity, turning Thaxter's agar deep wine-color and then black, potato-dextrose agar black, and corn-meal agar brownish red and green.

The pulvinate ascomata, variable in size (up to  $500\ \mu$  in diameter  $\times$   $40\text{--}80\ \mu$  in height) (FIG. 2, J), are usually subepidermal, sometimes subcuticular or intraepidermal, and composed of small, oliveaceous pseudoparenchymatous cells. The ascomata contain few, to numerous asci scattered irregularly in the stromatic tissue, are


 FIG 3 *Elsinoc* on *Sesbania* and *Cinnamomum*

frequently crowded, and with walls touching. The asci are globose to ovoid ( $20-36 \times 12-20 \mu$ ) (FIG 2, 'F'), and become elongated  $48 \times 8 \mu$  in water upon rupture of the inelastic outer wall. They are filled with eight clavate, hyaline ascospores ( $15-17 \times 4-6 \mu$ ),

usually four to five septate, which become muriform (FIGS. 2, K and 3, C). The longitudinal septum is usually in one cell, but occasionally more cells will be vertically septate. The ascospores are usually curved and deeply constricted at the middle septum, and are surrounded by a gelatinous envelope.

Acervuli are inconspicuous, being present on the same spots as the ascomata (FIG. 2, L). In a moist chamber acervuli develop into protruding fan-shaped sporodochia composed of a palisade layer of amber conidiophores and an amber pseudoparenchymatous base. Conidia were not observed on lesions, but when produced in culture from single-ascospore isolates these conidia were hyaline, oblong-ellipsoid, typically biguttulate, and continuous ( $4-6 \times 2-3.5 \mu$ ).

Pycnidia originate as swellings in the hyphae, as illustrated in the case of *Elsinoë australis* Bitanc. and Jenkins (2, pl. 7, E). These swellings are greenish at first, blacken with age (and may be  $20 \mu$  in diameter or larger), and finally become thick-walled and septate (FIG. 1, E). On corn-meal agar they coalesce, forming large black masses with the limits of an individual body obliterated. Hyaline, ellipsoid, bacteria-like spores ( $1.8-2.5 \times 0.5 \mu$ ), greenish in mass, are produced in the pycnidia (FIG. 1, F); these spores have not been observed to germinate.

### *Elsinoë cinnamomi* Pollack and Jenkins sp. nov.

Maculae in foliis amphigenae, usque 3 mm. diam. parcae vel numerosae, superne conspicuiores, plerumque succineae, nigrescentes, interdum centro albidae, margine frequenter lutescente; ascomata pulvinata, usque  $500 \mu$  diam.,  $40-80 \mu$  crassa, interdum coalescentia; asci saepe numerosi,  $20-36 \times 12-20 \mu$ ; ascosporae clavatae, hyalinae, 4-5 septatae, cum una vel pluribus cellulis longitudinaliter septatis, ad septum centrale constrictae, saepe curvatae,  $15-17 \times 4-6 \mu$ ; acervuli indeterminati expositi; conidia in culturis, hyalina, oblongo-ellipsoidea, saepe biguttulata, continua,  $4-6 \times 2-3.5 \mu$ ; pycnidia in culturis nigra, variabilia, coalescentia; pycnidiosporae ellipsoideae, hyalinae,  $1.8-2.5 \times 0.5 \mu$ .

DISTRIBUTION: On leaves, including petioles, and young stems of *Cinnamomum camphora* (L.) T. Nees and Eberm. (Lauraceae), causing scab of camphor-tree, Mississippi, U. S. A.

SPECIMENS EXAMINED: Ocean Springs, Miss., January 21, 1944,

L. A. Mayer 525; January 22, 1944, A. W. Blizzard 1118; March 16, 1945, Mayer 525A (Type, in Mycological Collections 90137).

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NEERING,  
BELTSVILLE, MD.

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# EXPLANATION OF FIGURES

FIG. 1. A-D, *Elsinoë sesbaniae* on *Sesbania exaltata*. A, cankered stems; a, from A. W. Blizzard 565; b, from L. A. Mayer 1211A,  $\times 1$ . B, section of ascoma embedded in tissue of canker, from Blizzard 565; a, epithecium; b, ascospores,  $\times 600$ . C, conidia, from Mayer 1211,  $\times 600$ . D, Month-old cultures from Blizzard 565; a, on Thaxter's medium; b, on potato-dextrose agar,  $\times 1$ . E and F, *Elsinoë cinnamomi* on *Cinnamomum camphora*. E, a, vertical section through pycnidial developments on the surface of an old culture; b, pycnidiospores,  $\times 260$ . F, same as E, b,  $\times 570$ . Photographs A and D by R. L. Taylor and B, C, E, and F by Limber.

FIG. 2. *Elsinoë cinnamomi* on *Cinnamomum camphora*. A, spots on upper surface of specimen Blizzard 1118,  $\times 1$ . B, part of A,  $\times 3\frac{1}{2}$ . C, culture from single ascospore on Thaxter's medium, dark masses of pycnidia visible on surface,  $\times 1$ . D, a, pycnidial masses on the upper part of C,  $\times 3\frac{1}{2}$ . E and F, leaf spots on Mayer 525A,  $\times 1$ . G, same as E, showing numerous black ascomata on marginal zone of the four white-centered spots,  $\times 14$ . H, spots on lower surface of a leaf of Mayer 525A somewhat obscured by a secondary dark hyphomycete,  $\times 1$ . I, ascus with ascospores,  $\times 570$ . J, ascoma from Mayer 525A in section; a, asci; b, upper epidermis of leaf,  $\times 260$ . K, ascospores,  $\times 570$ . L, somewhat indefinite stromatic mass, representing conidial (*Sphaceloma*) stage of *Elsinoë*,  $\times 570$ . M, conidia from an old culture.



× 570. N, ten-day-old colony, individual thalli marking the position of the discharged ascospores; *a*, high lights indicating copious, viscid, transparent substance covering the thalli and spreading beyond, × 10. Photographs (A-H and N) by Taylor and (I-M) by Limber.

FIG. 3. A and B, *Elsinoë sesbaniae*. A, ascospores. B, *a*, conidia, and *b*, conidiophores produced in culture. C-E, *Elsinoë cinnamomi*. C, ascospores free from ascus. D, ascospores as grouped in ascus. E, *a*, conidiophores, *b* and *c*, conidia produced in culture, *b*, conidium bearing two secondary conidia. (A, B, D and E 4.3 mm. = 1  $\mu$ ; C, 3.5 mm. = 1  $\mu$ .) Drawings by Limber.

# PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XLI. CATINELLA NIGRO-OLIVACEA

FRED J. SEAVER

(WITH 1 FIGURE)

One of the widely distributed, frequently collected, easily recognized, much named, and probably the most kicked around species of inoperculate cup-fungi is the species which forms the subtitle of the present paper. Specimens have been collected from Manitoba to Newfoundland, south to Louisiana, Alabama and the islands of Jamaica and Cuba. It has been described under at least nine different specific names and placed in eleven different genera, finally, very fittingly, made the type of a new genus by Boudier.

It has been illustrated several times in Europe but, so far as the writer is aware, never before in this country. A description and synonymy were presented by E. J. Durand (Bull. Torrey Club 49: 15-20. 1922). Durand regarded this as one of the Patellariaceae but the writer does not so consider it. It would seem to belong more properly with the Mollisiaceae although that family itself is not very clearly defined. The following is the writer's conception of the genus and its type species:

CATINELLA Boud. Hist. Class. Discom. Eur. 150. 1907.

Apothecia patellate or nearly so, dark greenish, subgelatinous; asci cylindric or subcylindric, 8-spored; spores simple, greenish; paraphyses filiform, granular within.

Type species, *Peziza olivacea* Fr. ex Batsch, Syst. Myc. 2: 142. 1822.

CATINELLA NIGRO-OLIVACEA (Schw.) Durand, Bull. Torrey Club 49: 16. 1922.

? *Peziza olivacea* Batsch, Elench. Fung. 127. 1783.

*Peziza nigro-olivacea* Schw. Schr. Nat. Ges. Leipzig 1: 121. 1822.

- Patellaria pulla nigro-olivacea* Fries, Syst. Myc. 2: 160. 1882.  
*Bulgaria nigrita* Fries, Elench. Fung. 2: 16. 1830.  
*Lemalis rufo-olivacea* Schw. Trans. Am. Phil. Soc. II. 4: 184. 1832.  
*Rhizina nigro-olivacea* Curr. Trans. Linn. Soc. 24: 493. 1864.  
*Peziza viridiatra* Berk. & Curt. Jour. Linn. Soc. 10: 369. 1868.  
*Patellaria violacea* Berk. & Br. Jour. Linn. Soc. 14: 108. 1875.  
*Patellaria hirneola* Berk. & Br. Jour. Linn. Soc. 14: 108. 1875.  
*Patellaria applanata* Berk. & Br. Jour. Linn. Soc. 14: 108. 1875.  
*Peziza fuscocarpa* Ellis & Holw. Jour. Myc. 1: 5. 1885.  
*Patellaria olivacea* Phill. Brit. Discom. p. 361. 1887.  
 ? *Humaria olivacea* Sacc. Syll. Fung. 8: 148. 1889.  
*Pezizula viridi-atra* Sacc. Syll. Fung. 8: 315. 1889.  
*Phaeopezia fuscocarpa* Sacc. Syll. Fung. 8: 474. 1889.  
*Bulgariella pulla nigro-olivacea* Sacc. Syll. Fung. 8: 638. 1889.  
*Bulgariella nigrita* Sacc. Syll. Fung. 8: 638. 1889.  
*Patinella violacea* Sacc. Syll. Fung. 8: 770. 1889.  
*Patinella olivacea* Sacc. Syll. Fung. 8: 770. 1889.  
*Patinella hirneola* Sacc. Syll. Fung. 8: 771. 1889.  
*Patinella applanata* Sacc. Syll. Fung. 8: 771. 1889.  
*Humaria marchica* Rehm in Rab. Krypt.-Fl. 1<sup>a</sup>: 952. 1894.  
*Phaeopezia marchica* Sacc. Syll. Fung. 11: 415. 1895.  
*Aleuria marchica* Sacc. & Syd. in Sacc. Syll. Fung. 16: 739. 1902.  
*Humaria fuscocarpa* Morgan, Jour. Myc. 8: 189. 1902.  
*Aleuria fuscocarpa* Sacc. & Syd. in Sacc. Syll. Fung. 16: 739. 1902.  
*Catinella olivacea* Boud. Hist. Class. Discom. Eur. 150. 1907.

Apothecia sessile, solitary or several crowded together, attached to the substratum by numerous radiating dark-brown fibers more conspicuous in young plants, at first subglobose and closed, then expanding with a permanently upturned margin, at first entirely greenish yellow, becoming darker green, finally blackish with an olive tint, when old the exterior brownish and furfuraceous and vertically striate, fleshy and somewhat gelatinous when fresh, brittle when dry; reaching a diameter of 1 cm. but usually much smaller; mycelial fibers about the base very coarse, straight or strongly kinked, septate, dark-brown, reaching a diameter of 10  $\mu$ , radiating 2-3 mm. beyond the base of the apothecium; asci nar-

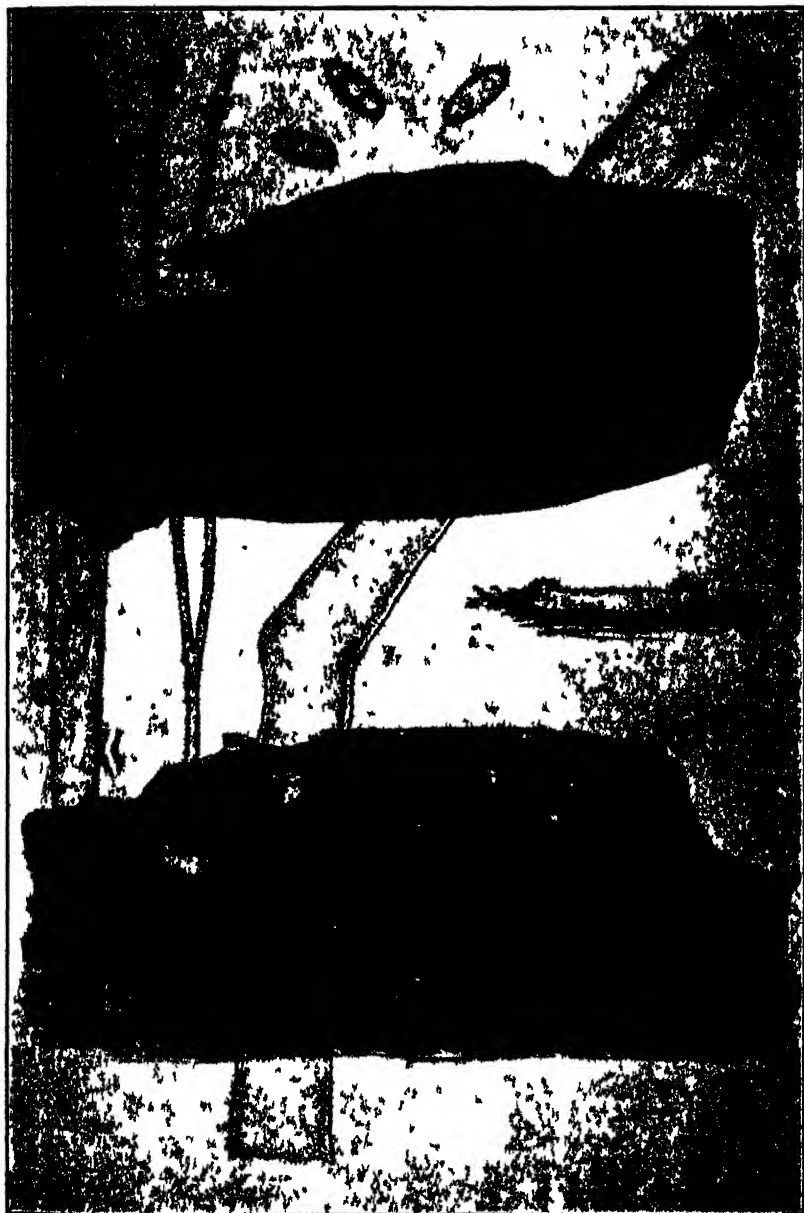


FIG 1 *Catinella nigro-olivacea*

rowly cylindric-clavate, 8-spored, reaching a length of 75-90  $\mu$  and a diameter of 5-6  $\mu$ ; spores uniseriate, irregularly ellipsoid, often slightly constricted near the center so as to appear slipper-shaped, containing one or two oil-drops, pale olive, becoming brown, 4-5  $\times$  7-10  $\mu$ ; paraphyses cylindric, simple or rarely branched.

On rotten wood of various kinds.

TYPE LOCALITY: Europe.

DISTRIBUTION: Throughout eastern N. America, West Indies, and Ceylon; also in Europe.

ILLUSTRATIONS: Batsch, Elench. *pl.* 12, *f.* 51; Boud. Ic. Myc. *pl.* 452; Trans. Linn. Soc. 24: *pl.* 51, *f.* 10-12.

EXSICCATI: N. Am. Fungi 2325; N. Dak. Fungi 28.

The species is easily recognized by its greenish apothecia and peculiarly shaped greenish spores.

#### EXPLANATION OF FIGURE

Above, photograph of apothecia on rotten wood, collected by W. A. Murrill in the island of Jamaica, about natural size. Below, photograph of rotten wood with apothecia from material collected in Nebraska by Leva B. Walker, about natural size. Left, drawing of ascus with spores and paraphysis. Right, diagram of a section of an apothecium. Center, drawing of a portion of hair from substratum.

# MYCOLOGIA

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## THE DEVELOPMENT AND GERMINATION OF THE INTRAEPIDERMAL TELIO- SPORES OF MELAMPSORELLA CERASTII<sup>1</sup>

STUART M. PADY<sup>2</sup>

(WITH 30 FIGURES)

The intraepidermal teliospores of the Pucciniastreae are of interest because of their peculiar habit of growth and wide variations which exist in the shape, size, and number of cells largely as the result of spatial relationships within the epidermal cells of the hosts. Since 1933 the writer has studied several species of these rusts and their manner of development has been ascertained. These include *Calyptospora goeppertiana*, *Milesia polypodophila*, *M. intermedia*, *M. fructuosa*, *Thekopsora vacciniorum* (5), *M. marginalis* (6) and *Hyalopsora aspidiotus* (7). This paper presents information on the development and germination of the teliospores of the closely related genus *Melampsorella*. Olive (4) has recently described the development and germination of the teliospores of *Thekopsora hydrangeae* in connection with a detailed study of the ontogeny of the sori on both the aecial and telial hosts. His account agrees in general with the method previously described, particularly with *T. vacciniorum*, but differs in some de-

<sup>1</sup> Contribution No. 473, serial No. 387, Department of Botany.

<sup>2</sup> This work was undertaken and completed while the author was head of the Biology Department at Ottawa University, Ottawa, Kans. Grateful acknowledgment is made to Dr. A. B. Martin for the use of certain laboratory equipment. Thanks are also due to Miss Georgia Anderson who was responsible for the preparation of many of the slides used in the investigation.

[MYCOLOGIA for July-August (38: 351-476) was issued August 2, 1946]

tails. A comparison of the results herein reported with those previously described, and particularly with *T. hydrangeae*, will be found later in this paper.

#### MATERIAL AND METHODS

Uredinial and telial material of *Melampsorella* was collected first on July 3, 1942, on a few plants of *Cerastium* sp. and *Stellaria* sp. in the Medicine Bow National Forest, Wyoming, in the vicinity of the University of Wyoming Summer Camp, at an altitude of 10,000 ft. On July 15 and subsequently it was found abundantly on *C. arvense* in a small area in this same general locality. The description of teliospore development and germination is based upon material on this host.

This material has been identified as belonging to the species *M. cerastii* (Pers.) Schroet. The status of the species of this genus is rather confused at the present time. Although Arthur (2) has made a single species, the writer has pointed out (8, 9, 10) that there are such differences on the aecial hosts in the type of pycnia, in the size, color, and markings of the aeciospores, as well as in the size and type of broom produced, that there are two species. In an attempt to prove this, two sets of infection experiments were undertaken, the first to obtain uredinial and telial material from aeciospores from infections on *Picea* and *Abies*. Some measure of success was obtained here; out of ninety sets of parallel inoculations, thirteen successful transfers were made with aeciospores from *Abies lasiocarpa* to *Cerastium arvense*, *Stellaria longipes*, and *S. umbellata*. From *Picea*, infections were negative, except in one doubtful case where a single plant of *S. longipes* became infected. The second set of inoculations were from telial material to *Picea* and *Abies*, half of the leaves of one plant being used on the former, the remainder on the latter. Results from this have so far been negative. Weir and Hubert (12), however, were successful in obtaining infections from aeciospores from *Picea* to *Stellaria borealis* and *S. longipes*.

The writer has examined and measured many urediniospores on the Caryophyllaceous hosts from his own collections and from the Arthur Herbarium, and has not been able to find any differences. The intradermal teliospores are, unfortunately, not suitable for tax-

onomic work because of their high degree of variability, due to their method of formation, which will be described later. Since the description of a second *Melampsorella* species requires authentic telial material, at present lacking, it is not possible to describe this species.

Boyce (3) considers *M. cerastii* to refer to the species on *Picea* sp., *Stellaria* sp., and *Cerastium* sp., whereas the other species is the old *Peridermium coloradense* (Diet.) A. & K. with pycnia and aecia on *Abies* and uredinia and telia unknown.

In the opinion of the writer, there are two species of *Melampsorella* with strikingly different pycnial and aecial morphology but identical in the uredinial and telial stages. Since final proof of this is still lacking, the writer is inclined to follow the temporary arrangement of Boyce. It should be emphasized here, however, that while the description below applies to *M. cerastii*, it is also, in the writer's opinion, true for the species of *Melampsorella* on *Abies*.

The diploid mycelium is perennial and systemic in *Cerastium arvense*. The presence of the mycelium alters the type of growth. Normally, flowering is profuse and continuous (FIG. 1A), but the infected plants are sterile or practically so. Infected plants tend to have more branches than normal plants, often having a bunched appearance which is probably a type of witches' broom. This is well shown in the plants in the photograph in figure 1B. The infected leaves are considerably reduced in size. The lower leaves are orange on the lower surface, due to the presence of teliospores, but uredinial sori are scattered over both surfaces. The upper leaves bear uredinia only, but the stems are usually sterile. Uredinia may be present also in the floral parts with the result that the flower becomes irregular and often abortive.

After freehand sections had revealed teliospores in various stages of development and germination, fixations were made in Fleming's Weak, Formalin Acetic-alcohol and Navachin's solutions and the material embedded in paraffin, sectioned at 10 $\mu$  and stained with triple stain.

In the region where this material was collected aecial infections, which result in witches' brooms on both *Abies* and *Picea*, were very numerous. The alternate hosts, *Cerastium* and *Stel-*



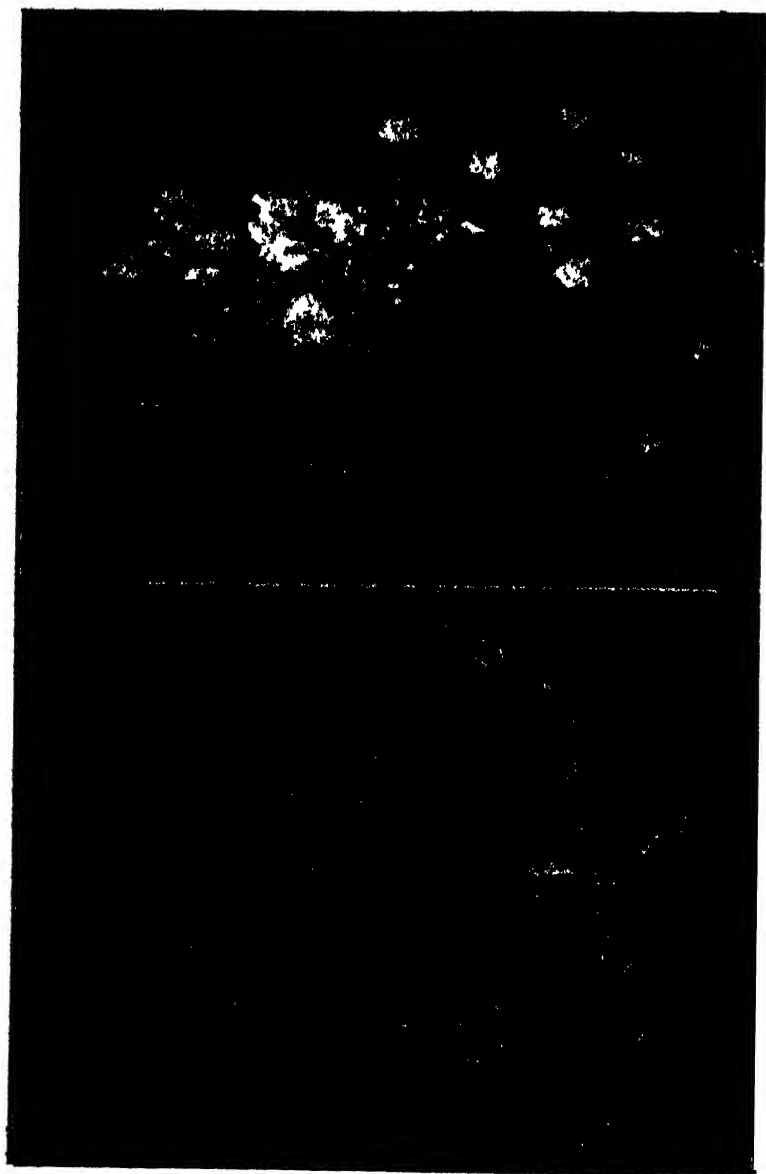


FIG. 1. *A*. Photograph of *Cerastium* sp. elev 10,000 ft. Medicine Bow National Forest, Wyoming. July, 1942. *B* Close-up of *Cerastium arvense* infected with *Melampsorella cerastii*. The lower leaves are orange on the lower surface due to teliospore formation. Uredosori are scattered over both surfaces of all leaves. Note witches' broom on older plant at right.

*laria*, are universally present, yet it was difficult to find *Cerastium* or *Stellaria* infected. It required a search of several weeks before sufficient plants were found in order to make fixations. Since the witches' brooms on *Abies* reach a diameter of one to three feet and those on *Picea* up to six feet, the number of aeciospores produced is prodigious; at times red clouds of spores are set free when the broom is disturbed. There are sufficient aeciospores present to inoculate every plant for miles around, yet aecial infections were comparatively rare. Evidently the conditions necessary for the establishment of the systemic mycelium in the crown and underground parts are extremely exacting.

#### PRIMORDIAL CELLS

The mycelium which ascends vertically in the meristems is also found in the cortex and pith of the stems. In the leaves it grows rapidly through the young tissues, especially in the loosely arranged tissues of the mesophyll. Hyphae are particularly evident in the region lying directly above the lower epidermis, indicating by their presence the region of primordial development. As soon as the leaf tissues are mature and probably earlier, there are indications of primordial cell formation. Hyphae grow to the lower epidermis, branching and spreading through intercellular spaces in close proximity to the epidermal cells. Hyphal cells which are in contact with epidermal cell wall now begin to enlarge. These enlarged hyphal cells become the primordial cells. Their formation is apparently continuous and new primordial cells are added for some time resulting in a layer of hyphal cells, which is very irregular, due to differences in age. Except for occasional breaks these cells form a continuous layer overlying the cells of the lower epidermis.

The primordial cells are highly irregular both in size and shape, depending apparently upon the number of primordial cells and the amount of space available. In spite of this diversity these cells tend to have a shape that is recognizable and to fall within a rather broad size range. They are roughly rectangular or brick-shaped in profile view, and square when seen in a transverse section. From above the primordial cells are seen to be densely packed, ranging from square to slightly oblong or rectangular. Most of the cells

are 10–17 $\mu$  long and 4–9 $\mu$  wide. Figure 2 demonstrates the wide variation found in a typical transverse section of this stage with abundant mycelium and young to mature primordial cells, with a typical one at *a*. This figure was drawn from a free-hand section and thus the nuclei are not shown. Typical cells from stained prepared material are shown in figures 3*B*, *a*, *c*; 4*a*, *b*; 9*b*; 11*a*; 16*b*, *c*; 17*e*, and in following figures.

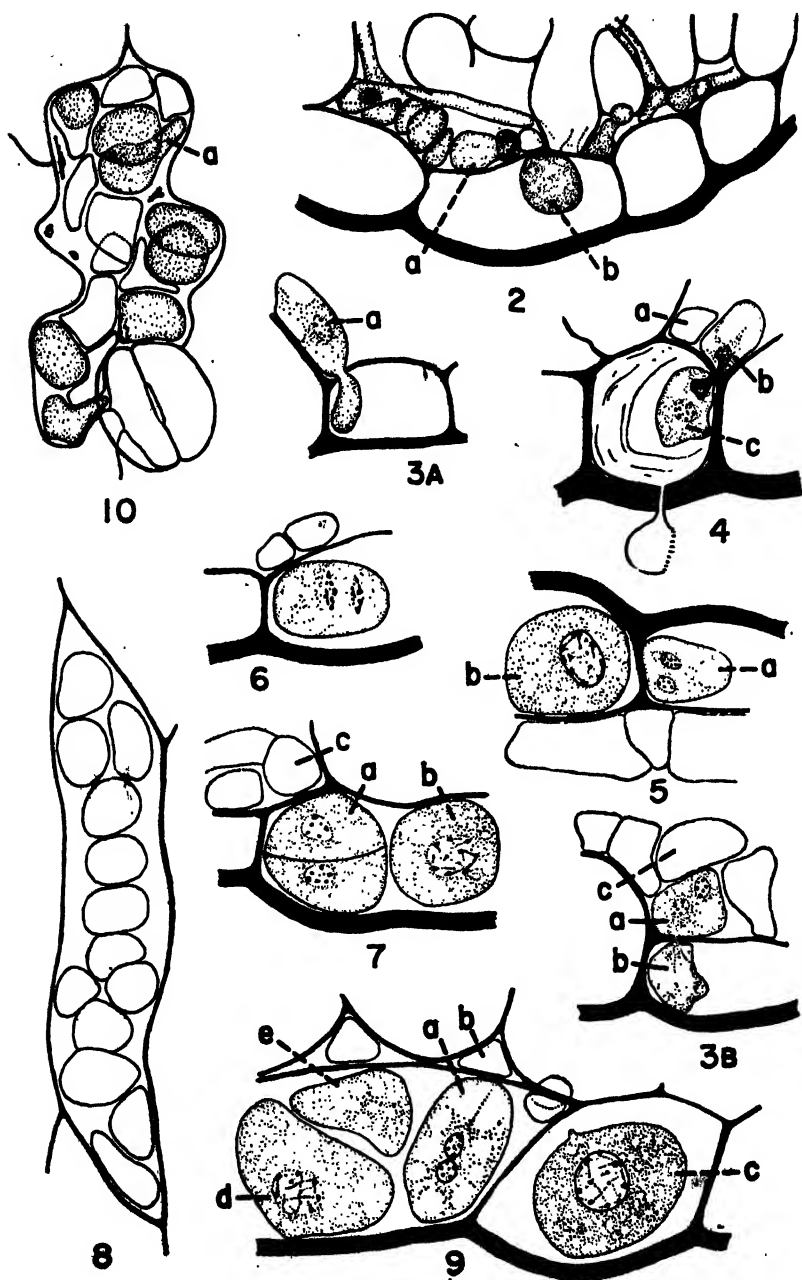
The origin of primordial cells from hyphal cells is indicated in figures 16*c* and 18*e* where the young primordial cell is clearly an enlargement of a hyphal tip. Note that a cell wall has not yet been formed in these figures, whereas in figure 14 the primordial cell (*g*) has been cut off from the hypha (*h*). The irregularity caused by adjacent host cell walls is illustrated in figures 9*b* and 15*a*. The binucleate condition is conspicuous and the dense cytoplasm is finely granular with prominent vacuoles (FIGS. 15*a*, 16*c*).

#### TELIOspore INITIALS

Penetration of the epidermal cell wall is rapidly accomplished and the cytoplasm flows in, forming a slender teliospore initial (FIG. 3*A*) which enlarges rapidly showing conspicuous vacuoles (FIG. 3*B*, *b*). The initial becomes spherical if spatial conditions permit (FIG. 2*b*), otherwise it conforms to the presence of the epidermal cell walls (FIG. 11) and neighboring initials or mature spores (FIG. 9*a*, 15*b*). The nuclei move downward in tandem

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FIG. 2. Freehand cross section from fresh material showing mycelium and primordial cells, *a*, and young teliospore initial *b*. 3*A*. Formation of teliospore initial from primordial cell *a*. 3*B*. Typical vacuolate initial with binucleate primordial at *a*, surrounded by other primordial cells, as at *c*. Nuclei preparing to enter initial. 4. Passage of nuclei from primordial cell *b*, to teliospore initial, *c*. 5. Teliospore initial *a*, in upper epidermis, which is uncommon. Note teliospore at *b*, and empty primordial cells below. 6. Young teliospore in which the dikaryon is undergoing simultaneous division to form a two-celled teliospore. 7. Typical unicellular teliospore (*b*) and atypical two-celled teliospore (*a*). Note empty primordial cell *c*. 8. Whole mount of lower epidermis from fresh material showing seventeen young teliospores. 9. Mature binucleate initial *a*, and primordial cell from which it had its origin. Young teliospore with fusion nucleus at *d*, and second layer of teliospores at *e*. 10. Group of mature and germinating teliospores in a single epidermal cell. Whole mount of fresh material. Some teliospores have already germinated and are empty. The spore at *a* is just beginning to germinate.



FIGS. 2-10.

formation (FIG. 14a), one nucleus squeezes through (FIG. 14d) elongating greatly in the process, and the second nucleus immediately follows (FIG. 4c). The remainder of the cytoplasm flows in, providing a binucleate cell with conspicuous vacuoles (FIG. 9a) which enlarges rapidly (FIG. 14c, e). This is the teliospore initial which will give rise directly to the teliospore (FIG. 5b) and this term is applied to this cell as long as the binucleate condition obtains. When nuclear division begins, the term teliospore is used.

In *Melampsorella cerastii* the teliospores are single celled (FIG. 8) and arise directly by growth and differentiation of the teliospore initial. Occasionally the initial will divide with small parallel spindles (FIG. 6) and a two-celled teliospore will result (FIG. 7a). In a few cases three- and four-celled teliospores have been found, but they are comparatively rare.

It is important to bear in mind that there is a continuous production of initials and new teliospore initials may develop alongside mature teliospores (FIG. 14) or even germinating teliospores (FIG. 15). When new initials develop in cells which now contain only old teliospores, they compress the walls of the latter, since the empty cell walls offer little resistance to the rapidly developing initial (FIG. 16f, g). With the first crop of initials the epidermal cell may be fairly well filled as in the cell shown in figure 8 which bears thirteen initials or young teliospores. Since this material was from a fresh preparation the nuclear situation could not be determined.

#### MATURE INTRAEPIDERMAL TELIOSPORES

At first the young uncrowded teliospores are spherical, but as enlargement continues, crowding occurs and the walls, which are thin, are flattened by mutual pressure (FIGS. 10, 15). Typically the teliospores are arranged in single palisade-like layers (FIGS. 8, 11, 13) but in some cases two layers are formed with one teliospore immediately below another (FIGS. 9d, e, 13b). Nuclear fusion was not observed, but it evidently occurs with rapidity since it was extremely difficult to find large binucleate initials (FIG. 9). Since the teliospores germinate without a resting period all that is required for the teliospore to germinate is a single diploid nucleus, and since there is no need for mitotic activity, the teliospores being

unicellular, syngamy apparently occurs as soon as the two nuclei have entered the initial.

The mature teliospores vary in height from 15–24 $\mu$  and in width from 10–15 $\mu$  but individual teliospores vary greatly in size since the number of initials and the size of the spores are limiting factors. In small cells a single teliospore may occupy the entire space (FIG. 11c) but in larger cells they are naturally more numerous (FIG. 13). There are thirteen in the epidermal cell shown in figure 8, and seventeen in figure 10. The number of teliospores per cell therefore cannot be estimated accurately. In figure 8, for example, the shape of the teliospore indicates a young uncrowded condition, whereas figure 10 shows the development of new initials and crushing of old teliospores which have germinated and are now empty. Usually the majority of the cells of the lower epidermis are filled and it is estimated that 80–90 per cent of the lower epidermis is involved. The fusion nucleus is relatively large and does not enter a resting phase but remains in a characteristic spireme stage, much like the leptonema stage, with delicate but distinct threads (FIGS. 5b, 9c). This stage could probably be designated as an interphase. As the teliospores enlarge, the epidermal cells become filled and the nucleus increases in size. Figure 11 is typical of the appearance of the teliospores at this state, with dense cytoplasm and a single large nucleus. The nucleolus is not evident here, nor is it ever, in fact, a conspicuous feature of the nuclei of the hyphae (FIG. 14h) or primordial cells (FIG. 11a).

The lower epidermis of the lower leaves is almost completely involved in the formation of teliospores. In only a few cases are initials (FIG. 5a) and teliospores (FIG. 5b) formed in the upper epidermis and here the area involved is definitely limited in size and the number of teliospores is correspondingly small.

#### ATYPICAL TELIOSPORE FORMATION

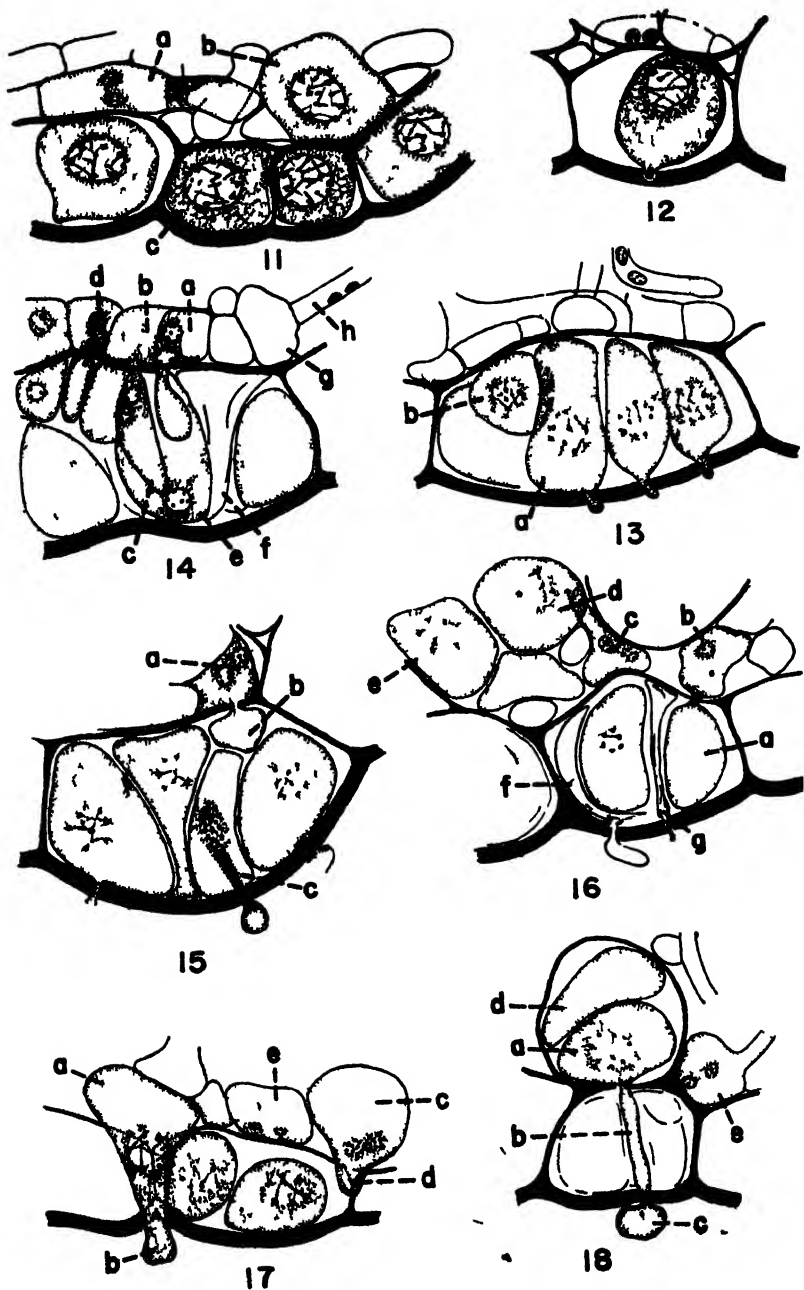
It is not uncommon to find mature teliospores developing at sites other than the interior of an epidermal cell. The more common situation is where a teliospore develops subepidermally in the intercellular space immediately above the lower epidermis which is already filled with teliospores (FIGS. 11b, 16d, e). The evidence

suggests that the primordial cell became the teliospore *in situ* since these spores are not accompanied by any empty cells of a precursor type. The greatly enlarged primordial cell in figure 11a will probably develop in a similar way. Occasionally, groups of teliospores will develop in the middle of a leaf. In a few cases teliospore initials have entered parenchyma cells in the mesophyll and teliospores have developed there (FIGS. 18a, d; 29d). Guard cells occasionally act as host cells, the enclosed spore conforming closely to the cell wall boundaries.

A rather peculiar situation is recorded in figure 30 which was fairly common in one particular collection. Evidently primordial cells had developed prolifically in the substomatal chambers, which in this case were close together. The result was that several layers of teliospores developed and their rapid expansion had disrupted the underlying stomata. The relationship between hyphal cells, primordial cells, and teliospores is clearly shown here. By simple enlargement some of the hyphal cells have become primordial cells (FIG. 30d, f, g); the latter two, however, have entered epidermal cells normally. Nuclear fusion and further enlargement would cause the cells to become teliospores *in situ* (FIG. 30a, b, c, e). Whether or not these would germinate normally was not de-

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FIG. 11. Group of mature teliospores with characteristic fusion nuclei. The origin of primordial cells (a) from hyphae is well shown in this figure. The atypical teliospore (b) is in the air space above the lower epidermis. 12. Single teliospore beginning to germinate. 13. Slightly later stage. A later-formed teliospore is shown at a lower level at b. 14. Cross section through an epidermal cell to show continuous production of new spores; a, d, typical primordial cells with very young initial; b, nearly empty primordial cell; and young teliospore initial c; e, young vacuolate initial; f, empty teliospores with crushed walls; g, typical primordial cell; h, hyphal cell. 15. Group of germinating teliospores, with young initial b, developing from primordial cell a; c, movement of cytoplasm into promycelium. 16. Cross section showing diversity of stages encountered in this material; c, very young primordial cell; b, mature primordial cell; a, young initial; d, e, mature subepidermal teliospores; f, g, old empty teliospores being crushed by growth of initials and teliospores. 17. Atypical teliospore, a, lying in subepidermal space, germinating by forcing promycelium b, between the epidermal cell walls. The teliospore initial c is sending up a papilla d, between the cell walls; e, primordial cell. 18. Intramesophyllar teliospores a, d. The former has forced a slender germ tube b, through the epidermis to form a young promycelium c; e, young primordial cell.



FIGS 11-18



terminated. This group of teliospores is suggestive of teliospore formation in the genus *Chrysomyxa*.

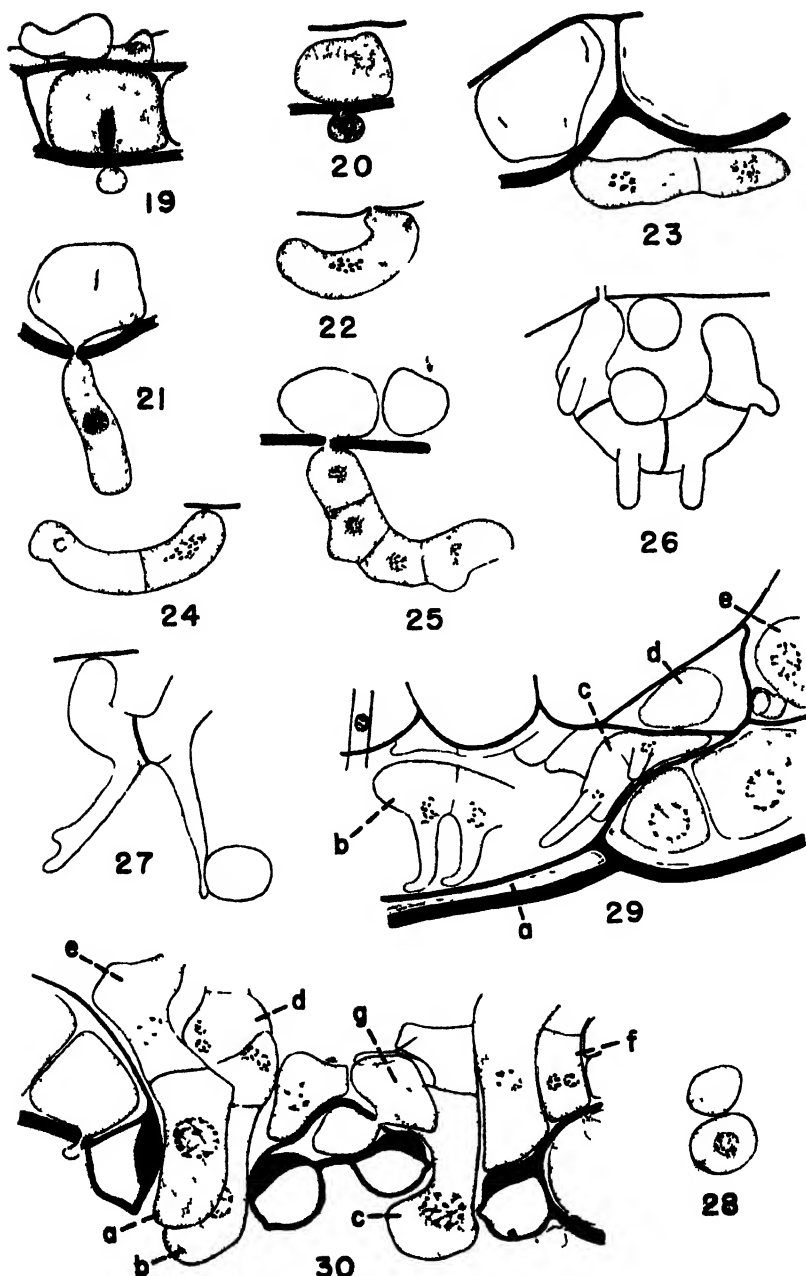
#### GERMINATION

When the teliospore is mature, which would be shortly after nuclear fusion, germination commences. The first evidence is in a small beak or papilla which arises from the spore and projects into the overlying epidermal cell wall. That the invasion is due to chemical rather than mechanical means is suggested by the halo in figure 12 which surrounds the papilla as it begins its passage. The penetration is soon accomplished and an opening is formed which can be identified readily in subsequent stages and through which the papilla emerges (FIG. 13). As the cytoplasm flows outward considerable enlargement of the papilla results and the promycelium comes into being (FIGS. 19, 20). The nucleus decreases greatly in size, the chromatin becoming aggregated into small bodies which have only a faint suggestion of a leptotene stage (FIG. 15c). It is possible that this stage represents the actual chromosomes or groups of chromosomes rather than a type of interphase. This appearance is retained as the nucleus which is now greatly reduced in size (FIG. 19), moves downward to the opening, and slips through to occupy the promycelium (FIG. 20).

The cytoplasm sometimes becomes aggregated below the opening in a densely staining band extending from the opening to the nucleus (FIG. 15c). In slightly later stages (FIGS. 19, 20) this band is absent, and it is not known whether this is confined to certain cells or if it occurs in all cells but is of short duration. In the ensuing growth period the teliospore is evacuated as the cytoplasm

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FIG. 19. Passage of the fusion nucleus into promycelium. 20. Nucleus at base of young promycelium. 21. Fusion nucleus at beginning of meiosis. 22. Meiotic anaphase. Promycelium typically recurved. 23. Two-celled promycelium. 24. Second division in the promycelium. 25. Four-celled promycelium with vacuolate cytoplasm. Sterigmata beginning to form. 26. Typical promycelium from fresh material with sterigmata and basidiospores. 27. Elongated sterigmata, occasionally forked. 28. Mature uninucleate basidiospores. 29. Abnormal germination. The sterigmata of promycelium *b* have crushed the epidermal cell *a*. The promycelium *c* may have arisen from the intramesophyllar teliospore at *d*. 30. Mass of hyphal cells in sub-stomatal chambers forming groups of abnormal teliospores *a*, *b*, *c*, *e*; *d*, enlarged hyphal cell. Note that even here epidermal cells are being entered in normal fashion from primordial cells *f*, *g*.



FIGS. 19-30.

moves outward into the enlarging promycelium with the nucleus occupying a central position (FIG. 21). The nucleus enlarges slightly (FIG. 21), forming a delicate network much like that described by Allen (1) for *Puccinia malvacearum*.

The first maturation division immediately follows with the meiotic spindle lying in the central part of the promycelium parallel to the long axis. The spindle is small and spindle fibers inconspicuous; the chromosomes, or groups of chromosomes, are drawn to the poles in an irregular fashion which seems to be typical of this group of fungi (FIG. 22).

Although this material had all stages of germination in abundance, late prophase and particularly metaphase were rare. It was thus not possible to obtain very much evidence as to the haploid and diploid chromosome number. Olive (4) has recently reported the haploid number to be four in the closely-related species *Thekopsora hydrangeae*. Savile (11) has also obtained this number for *Uromyces fabae*, *U. hyperici*, *Puccinia sorghi*, and *Melanopsora bigelowii*, as well as for *P. malvacearum*, which Allen (1) had earlier considered to be five. In *M. cerastii* the chromosomes were not sufficiently distinct for an accurate analysis, although the anaphase in figure 22 suggests that the number is small.

Two daughter nuclei are organized as the promycelium enlarges and a cell wall is laid down (FIG. 23). The second division follows (FIG. 24) and a four-celled promycelium results. The presence of the promycelia on the surface gives a greyish to pinkish cast to the under surface of the leaf which, up to this time, has retained its orange color. The mature promycelium is typically recurved (FIGS. 25, 26), the amount of curvature showing considerable variation. Even in the young promycelium this curvature is evident (FIGS. 22, 24, 25) suggesting that this structure is negatively geotropic. The nuclei are small but conspicuous and the cytoplasm conspicuously vacuolate (FIG. 25). In size the promycelia measured  $31-37 \times 7-9 \mu$ . On the ventral surface of the promycelium small protuberances are formed (FIG. 25) indicating the points of origin of the sterigmata. The sterigmata are elongated and of rather large diameter (FIG. 26); becoming tapered toward the tip (FIG. 27). Figures 26 and 27 were drawn from freehand sections of fresh material and nuclear details were not obtained. The

length of the sterigmata was, on the average, about  $7\ \mu$  but in certain cases that length was more than doubled. For example in figure 27 the sterigma on the right measured  $17\ \mu$ , whereas the forked sterigma on the left was  $15\ \mu$ . Savile (11) has pointed out that the length of the sterigmata in certain rusts depends largely upon whether or not there is water on the surface, and this explanation could probably explain the variation that exists here. Certainly the profusion of recurved promycelia on the lower surface would tend to retain a film of water for a considerable period. The passage of the nuclei into the basidiospores was not observed in this material. The basidiospores are round to slightly oblong, measure  $7-9 \times 6-8\ \mu$ , and are uninucleate (figs. 26, 27, 28). No evidence has been obtained for further nuclear divisions either in the promycelia or basidiospores.

Allen (1) has shown that the basidiospores of *Puccinia malvaearum* become binucleate before germination. Savile (11) has confirmed this for this species and has shown it to be true also for *Uromyces lespedezae-procumbens* and *Melampsora bigelowii*, and has even reported a quadrinucleate basidiospore. Olive (4) in *Thekopsora hydrangeae*, which is very similar to *M. cerastii* throughout, found that the basidiospore is originally binucleate but one of the nuclei degenerates, restoring the uninucleate condition. Although no evidence of a second division has been found in *M. cerastii* it is not inconceivable that the same condition obtains here as for *T. hydrangeae*.

Occasionally subepidermal teliospores which are lying above the junction of two epidermal cells will attempt to germinate by forcing their way between the cells to the surface. In figure 17, the teliospore, *a*, has already reached the surface and is producing a promycelium, *b*. The teliospore initial *c* is likewise pushing toward the surface at *d*. Teliospores in the cells of the mesophyll may attempt to produce an external promycelium by forcing their way to the surface. In figure 18, two teliospores *a*, *d*, are in a mesophyll cell, and *a* has produced a long slender germ tube *b*, much like an infection hypha, which has grown completely through the epidermal cell to reach the surface and produce a normal promycelium. Evidently it is necessary for the teliospore to be in close contact with the host cell wall in order to achieve successful

penetration. In the atypical teliospore *e* in figure 29, a slender promycelium has been formed but is held within the boundary of the cell wall. In this same figure portions of two promycelia are drawn at *b* and *c* which were formed above the epidermis in an intercellular space. When the sterigmata were formed, and note that they are produced on the ventral surface, the force of the developing sterigmata crushed the underlying epidermal cell.

#### DISCUSSION

The development and germination of the teliospores of *Melampsorella cerastii* is in agreement with previous investigations of members of the Pucciniastreae with intraepidermal teliospores. Because of their unusual position and manner of development all of the available information on such forms has been summarized in Table 1.

The most striking features of the table seem to be, first: the general similarity that exists in the nine species that have been described with binucleate primordial cells which are closely applied to the epidermal cell wall and through which entrance is effected with the subsequent formation of a teliospore initial that in most cases divides to produce a multicellular teliospore with thick or thin walls which in turn is highly irregular due to conformity with the confining cell walls and competing spores within the small cell. The second feature is the diversity that exists in the time of formation and also in the time of germination. At one extreme there are the forms which produce the teliospores as soon as the leaves unfold, and proceed immediately to germinate, as *Hyalopsora aspidiotus* and *M. cerastii*, then a second group which produces teliospores during the season, germinating the following spring as *Thekopsora vacciniorum* and *T. hydrangeae*, and a third group in which the teliospores develop on green overwintered leaves, germinating at once, as *Milesia marginalis*, *M. intermedia*, and *M. fructuosa*. *Calyptospora goeppertiana* is in a separate group because of the formation of teliospores in the spring when the stems develop, but with germination being delayed until a year later. Of the nine species whose development has been studied only three are alike, *Milesia polypodophila*, *M. intermedia*, and *M. fructuosa*; all others show a wide variation in kind of spore produced, and in the

TABLE 1  
 COMPARISON OF SPECIES IN PUCCINIASTREAE WITH INTRAEPIDERMAL TELIOSPORES

	Primordial cells	Type of teliospore	Epidermis		Time of formation	Germination	Author
			Lower	Upper			
<i>Melampsorella cerastii</i>	present	unicellular, thin-walled	present	some	spring, current season	follows immediately	Pady
<i>Hyalopezora aspidiotus</i>	do.	multicellular, thin-walled	present	—	do.	do.	Pady (7)
<i>Thekopsora hydrangeae</i>	absent	multicellular, thick-walled	sometimes	present	fall	on overwintered leaves	Olive (4)
<i>Thekopsora vacciniarum</i>	present	multicellular, thin-walled	present	few	do.	do.	Pady (5)
<i>Milesia* marginalis</i>	do.	do.	do.	some	following spring on overwintered leaves	follows immediately	Pady (5, 6)
<i>Milesia polypodophila</i>	do.	do.	do.	—	do.	do.	Pady (5)
<i>Milesia intermedia</i>	do.	do.	do.	—	do.	do.	Pady (5)
<i>Milesia fructuosa</i>	do.	do.	do.	few	fall	on overwintered leaves	Pady (5)
<i>Calypsotheca goeppertiana</i>	do.	multicellular, thick-walled	in epidermis of stems		spring	on overwintered stems	Pady (5)

time when the teliospores are formed, but are particularly diversified as to the time when germination takes place (Table 1).

It will be noted that *Hyalopsora aspidiotus* and *M. cerastii* are very similar. The mycelium in both cases is systemic and diploid; the teliospores develop in the lower epidermis of the young leaves as they open in the spring; the teliospores are thin walled and germination follows without a resting period. They are unlike only in the number of cells found in the mature teliospore. This would indicate a fairly close relationship which is still further strengthened by the fact that aecial hosts are the closely related genera *Abies* and *Picea* (Table 2).

In Table 2 a summary has been made of the species of rusts with intraepidermal teliospores in order to emphasize the close relationship that exists among the hosts. For the sake of completeness the second species of *Melampsorella*, as yet unnamed, has been included. It is of interest to note that for all ten species the aecial hosts are confined to three genera of the Gymnospermae and two of these, *Picea* and *Abies*, are closely related. Moreover, seven of the ten species are found on *Abies*, two are on *Tsuga*, and the remaining one on *Picea*. Even among the telial hosts only five families are present, five species going to fern genera in the Polypodiaceae, the remainder going to members of the Cypripodaceae, Vacciniaceae, Ericaceae, and Hydrangeaceae in the Angiospermae.

Perennial mycelium especially in the diploid phase is unusual, yet in seven cases there is a perennial mycelium; in *Melampsorella* in the aecial and telial hosts; in *Hyalopsora* in the telial host; *Milesia polypodophila* in the aecial host and *Calyptospora* in the telial host. The tendency is for this perennial mycelium to form witches' brooms, particularly where the perennial mycelium is systemic. The one exception to this is *Hyalopsora aspidiotus* which does not show any witches' broom effect. This is doubtless due to the fact that the telial host is a fern, *Phegopteris*, which lacks permanent aboveground parts, dying back each fall to the underground rhizome. The most conspicuous witches' brooms are in the genus *Melampsorella* in which we have witches' brooms on both hosts, those on *Picea* and *Abies* growing for many years and often reaching a remarkable size (10).

Olive (4) has recently described the development of the spore

TABLE 2  
HOST RELATIONSHIPS OF THE SPECIES OF PUCCINIASTREAE WITH INTRAEPIDERMAL TELIOSPORES

Rust species	Aerial host(s)	Haplloid mycelium	Witches' brooms	Telial host(s)	Diploid mycelium	Witches' brooms
<i>Melampsorella cerastii</i>	<i>Abies</i> sp.	perennial, locally systemic do.	conspicuous, up to 3 feet diameter	<i>Cerastium</i> sp., <i>Stellaria</i> sp.	systemic perennial	diffuse, small
<i>Melampsorella</i> sp. ( <i>Peridermium coloradense</i> )	<i>Picea</i> sp.		very large, up to 6 feet diameter	<i>Cerastium</i> sp., <i>Stellaria</i> sp.	systemic perennial	diffuse, small
<i>Hyalopsoa aspidiotus</i>	<i>Abies balsamea</i>	grows 2 yrs.	—	<i>Phegopteris dryopteris</i>	systemic perennial	—
<i>Thekopsora hydrangeae</i>	<i>Tsuga canadensis</i> , <i>Tsuga caroliniana</i>	—	—	<i>Hydrangea arborescens</i> , <i>H. radicata</i> , <i>H. cinerea</i>	systemic perennial overwinters	—
<i>Thekopsora vacciniorum</i>	<i>Tsuga canadensis</i>	—	—	<i>Vaccinium</i> sp., <i>Azalea</i> sp., and other genera	overwinters	—
<i>Milesia polypodophila</i>	<i>Abies balsamea</i>	perennial	loose type	<i>Polypodium virginianum</i>	overwinters	—
<i>Milesia marginalis</i>	<i>Abies balsamea</i>	—	—	<i>Dryopteris marginalis</i>	overwinters	—
<i>Milesia intermedia</i>	<i>Abies balsamea</i>	—	—	<i>Dryopteris intermedia</i>	overwinters	—
<i>Milesia fructuosa</i>	<i>Abies balsamea</i>	—	—	<i>D. americana</i>	—	—
<i>Calyptopora goeppertiana</i>	<i>Abies</i> sp.	—	—	<i>Vaccinium</i> sp.	systemic perennial	large



forms in the long cycled rust *Thekopsora hydrangeae*. He was able to follow the development of the teliospores as they matured at the end of the growing season and their subsequent germination the following spring. Although his account follows the same general pattern of development as found in other species with intra-epidermal teliospores (Table 1), it is most similar to that of *T. vacciniorum* which has been previously described (5) but from which it differs in several respects. In the first place, primordial cells are not specifically described by Olive but his figures show clearly the presence of similar structures. Since the teliospores are in the upper epidermis the absence of intercellular spaces results in slender vertical hyphae from which the teliospores arise. A similar situation was described for *T. vacciniorum* (5) with the difference that in the intercellular spaces above the lower epidermis typical primordial cells were produced. In figure 130 in Olive's paper a teliospore is shown in the lower epidermis, but immediately above is a group of empty hyphal cells which are similar to the primordial cells described in this paper. Intramesophyllar teliospores also occur in *T. vacciniorum* and Olive has shown them also to be present in *T. hydrangeae*. His figures 131 and 132 show spores in the palisade cells, whereas the atypical teliospores found in the outer region of a uredinial sorus might be compared with the teliospores in the substomatal hyphal complex in *Melampsorella* (FIG. 30).

An interesting characteristic described by Olive (4) is the simultaneous passage of the nuclei from the primordial cells into the teliospore initials, the nuclei going through as a very attenuated team, whereas in *Melampsorella* the nuclei pass through in typical tandem fashion (FIGS. 4, 14d).

An unusual feature of teliospore development in *M. cerastii* is that several crops are produced in successive waves during the early part of the growing season. Most rusts produce a single crop of teliospores as the host approaches maturity, example *Puccinia graminis*. In the group with intraepidermal teliospores *Thekopsora vacciniorum*, *T. hydrangeae*, *Milesia fructuosa* are "normal" in this respect at least (Table 1). Even in the closely related species *Hyalopsora aspidiotus* only one group of teliospores develops and germinates. The growing habits of the hosts may.

partially explain this difference. The host of *H. aspidiotus*, *Phegopteris dryopteris*, is a fern with a small frond which unfolds at one time, allowing the systemic mycelium to invade the entire leaf rather uniformly. *Cerastium arvense*, the host of *M. cerastii*, is a member of the Caryophyllaceae with indeterminate growth, the lower leaves being the oldest with the youngest leaves nearest the tip, except where axillary growth has provided new leaves. The lower leaves of the plant therefore are invaded first and the mycelium is soon well established and teliospore formation follows immediately, which is indicated by deep orange color of the lower surface. Germination begins first in these lower leaves since these leaves and their enclosed teliospores are the oldest. It is at this point that the difference occurs. As the host cells become emptied through the process of germination new teliospores are continually added (FIGS. 5, 14-16) and apparently this process continues over a period of several weeks. *M. cerastii* thus differs from other related forms in having an extended period of continuous teliospore production.

In previous papers (6, 7) attention was called to the peculiar nuclear situation which was found in the mature spores, namely, that instead of being in a resting condition, the chromatin of the mature teliospore was in prophase with a distinct spireme. This is not difficult to understand in those forms like *Hyalopsora aspidiotus* where germination follows immediately, but in a species like *Milesia marginalis* where a resting period followed it was rather surprising. In *M. cerastii* the mature fusion nucleus has never been found other than in a well-defined spireme (FIG. 11).

Olive (4) is not clear as to the stage in which the teliospore nucleus passes the winter, although his figures 125-128 show details of the fusion nucleus which is in the spireme stage.

From the cytological standpoint *Melampsorella cerastii* is very similar to the other rusts listed in Table 2, particularly with reference to the details of fusion and meiosis in the promycelia. In one respect, however, it was unusual, namely, in the absence of a nucleolus. The material fixed in Fleming's Weak and F: A. A. was carefully examined for this structure. In other rusts, such as *Hyalopsora* and *Milesia*, the nucleolus is conspicuous up to and including the early stages of nuclear fusion. Moreover, with Flem-

ing's fixatives and the triple stain the nucleolus stands out brilliantly. In this material, however, careful search has not revealed its presence.

According to Savile, the so-called nucleolus of the rusts is not a true nucleolus but an endosphere surrounded by an ectosphere, the true nucleolus being described as a small granule within the endosphere. Rust nuclei exist in two phases, the large expanded type with definite endosphere (nucleolus) surrounded by the ectosphere which is often hyaline, and the small unexpanded type which consists solely of the endosphere. The latter type is found throughout most of the life cycle and is associated with passage through a very small pore. The expanded form originates from the endosphere by the formation of an outer ectosphere into which all of the chromatin passes. In reverting back to the unexpanded form, the endosphere is discharged and the ectosphere reforms into a small nucleus about the size of the original endosphere. Endospheres were not found in *M. cerastii* and it is not possible with this material to confirm this endosphere hypothesis. That the two types of nuclei probably do exist in *M. cerastii* is suggested from a study of the nuclear sizes which show both small unexpanded and large expanded nuclei, but an endosphere as such is completely lacking. The presence of a so-called true nucleolus in the form of a granule also could not be confirmed.

#### SUMMARY

The teliospores of *Melampsorella cerastii* are developed in the lower epidermis of the young leaves of *Cerastium arvense* in the spring from a systemic perennial mycelium. Hyphae mass up above the cells of the lower epidermis and from certain hyphal cells of the fungus enlarged binucleate primordial cells are formed. Each primordial cell penetrates the host cell wall and the contents flow in to form a teliospore initial which, by growth and differentiation, develops directly into a single-celled thin-walled teliospore.

Following nuclear fusion the teliospore immediately germinates, producing a slender recurved promycelium into which the fusion nucleus migrates. Meiosis occurs here and four uninucleate basidiospores are produced.

Teliospores completely fill all of the cells of the lower epidermis of the lower leaves, giving the leaf an orange color. Some telio-

spores are formed in the middle leaves but are lacking in the upper leaves. Teliospore formation is continuous during the first few weeks and new initials are formed in the cells as the teliospores germinate.

Comparisons were made with the other rust species with intra-epidermal teliospores which have been examined cytologically. *Melampsorella cerastii* is similar in its general development but differs principally in that the teliospore is unicellular.

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#### EXPLANATION OF FIGURES

Note: All figures are drawn with camera lucida and are oriented in their natural position, that is, with the lower epidermis facing the bottom of the page. Figures 1, 8, 10  $\times$  513, figures 2-7, 9  $\times$  1153, all other figures  $\times$  990.

# THE TAXONOMIC POSITION OF PHOLIOTA MUTABILIS AND RELATED SPECIES

ROLF SINGER AND ALEXANDER H. SMITH \*

(WITH 10 FIGURES)

It has been recognized for a long time that the genus *Pholiota* in the Friesian sense is artificial. The characters of the veil were greatly overemphasized by Fries and even more so by Schroeter and others. In Fries' arrangement *Rozites caperata* was placed in the same genus as *Pholiota squarrosa* simply because the partial veil, when it breaks, leaves an annulus on the stipe. It is as logical to insist that these two species be in the same genus because of this one similarity as it is to insist that certain species of *Lepiota* be excluded from that genus simply because the veil tissue is delicate and does not remain on the stipe in the form of a membranous ring when the veil breaks. In any practical classification these *Lepiota* are grouped together because of their obvious affinities with species possessing truly membranous rings. The dark spored agarics, in particular *Psathyrella* emend. Kühner, furnish another excellent example of a very homogeneous series of fungi in which the disposition of the veil remnants on the stipe is not important at the generic level. In *Psathyrella* it appears logical, in order to arrive at a natural and usable classification, to group together parts of several of the Friesian genera which lack fundamentally distinctive characters. The fragile, annulate *Stropharia*, for instance are now placed in *Psathyrella*. However, in *Pholiota* the opposite situation has prevailed. Here it is necessary to divide the genus into several groups at the generic level if one is to arrive at the most practical and natural grouping of the various species. Some of the groups already segregated from *Pholiota* by others are

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*Agrocybe* Fayod (1889), *Gymnopilus* Karsten (in the sense of *Fulvidula* Romagnesi), *Rozites* Karsten, and *Pholiotina* Fayod. This has left two groups of species in what might be regarded as *Pholiota* sensu stricto. One of these groups is relatively large and is typified by *P. squarrosa* (Muell. ex Fr.) Quél., *P. squarrosoides* Pk., etc. The best known representative of the second is *P. mutabilis* (Schaeff. ex Fr.) Quél. It differs from species in the first group in having spores with a distinct germ pore at the apex much as in species of *Psilocybe*, and in having the epicutis of the pileus composed of narrow appressed hyphae. In addition the pilei are hygrophanous and naked, and frequently have translucent striae on the margin caused by the gills showing through the thin, moist flesh. However, *P. mutabilis* has never been separated from *Pholiota*, no doubt because it was the only species known to possess the above characters and because the squarrose scales of the stipe made it easily included in the generic description of *Pholiota* sensu stricto.

However, these are not valid reasons for continuing to include *P. mutabilis* in *Pholiota*. Our study has brought to light four species which have practically all the important anatomical and macroscopic characters in common with *P. mutabilis*. In two of these the veil is too poorly developed to leave scales on the stipe. One has scales which are smaller and more indistinct than those of *P. mutabilis*, and which are usually confined to a narrower zone beneath the annulus. In all these species we have noticed a slight viscidiness caused by the subgelatinous nature of the cuticle. The layer, however, is not thick enough or sufficiently gelatinous to render the caps distinctly viscid under all conditions. All four species have small, thin, hyaline cheilocystidia and small ovoid spores characterized by a broad germ pore. The known species are all lignicolous and typically vernal in their fruiting habits. Later fruiting periods are known for most<sup>1</sup> but our information indicates that their peak of fruiting-body production is reached during the spring.

It is interesting to note that these characters are also found in most species of a group of dark spored agarics which some authors

<sup>1</sup> In a species found in Florida collected in July 1943 there is not enough data available to indicate a seasonal fruiting pattern.

recognize as the genus *Deconica*.<sup>2</sup> When one considers the problem of the possible relationship of these two groups he is at once impressed by their similarity in all fundamental characters except the color of the spore deposit, and a survey of the literature causes one to question whether the color of the spore deposit in the *Pholiota-Flammula-Naematoloma-Psilocybe* (-*Deconica*)-series of species is really significant. Smith in 1943 described two species of *Naematoloma*<sup>3</sup> under the name *Hypholoma* in which the spores were typically dull brown in deposits. It has long been known that *Naematoloma elongatum* has a typically brown spore deposit (it has been described as a *Naucoria*). In addition, a number of species which have been described in *Naucoria* have been found to belong in *Psilocybe* (*Deconica*) or in *Naematoloma*. This clearly indicates that color of the spore deposit is not a sufficiently distinct character for grouping species into genera in those fungi most closely related to *Pholiota mutabilis*. In view of the striking similarities of the morphological and anatomical characters of the two groups this situation leads us to regard them as very closely related and brings up the question of the relationships of *Pholiota* sensu stricto, *Flammula* sensu stricto, *Stropharia*, *Naematoloma* and *Psilocybe* (including *Deconica*). These genera need to be re-studied critically with an eye to reevaluating the use of the annulus as a generic character for separating *Pholiota* and *Flammula* on the one hand and *Stropharia* from *Naematoloma* and *Psilocybe* on the other. We are by no means the first to see the need for this study—it has been very ably pointed out by Kühner (1936). We strongly doubt whether it is desirable to continue to maintain both *Pholiota* and *Flammula* as separate genera. The only difference between them as defined here is in the degree to which the veil is developed. The number of species in which the veil is “subannular” is greater than either of the extremes. In a number of species the presence of an annulus is a variable character, as in *Pholiota malicola*. In the purple brown spored series, however, it appears desirable to recognize both *Naematoloma* and *Stropharia*.

<sup>2</sup> The senior author recognizes *Psilocybe* and *Deconica* as separate genera whereas the junior author places them in one genus, *Psilocybe*.

<sup>3</sup> *Naematoloma olympianum* Smith, comb. nov. (*Hypholoma olympianum* Smith, *Mycologia* 36: 248 (1934) and *N. subochraceum* Smith, comb. nov. (*Hypholoma subochraceum* Smith, *Ibid.* p. 251).

Returning to a consideration of the similarities and possible relationships of the rusty brown and dark-spored groups of genera previously mentioned, we can go one step farther and consider a group of species which Patouillard named *Melanotus*. These have fruiting bodies resembling those of *Crepidotus*, but the species are actually pleurotoid *Deconicae*. We accept this genus. Parallel to it the senior author has found an unnamed species confused with *Crepidotus* by some authors. It has thick-walled, smooth spores and falls in this group, but is more closely related to the Pholiotoideae of the senior author's classification. We do not mean to suggest that spore color is of no value as a character in this particular group, and we do not recommend that parallel genera separated mainly by spore color be united into large genera. But it does appear that after consideration of the very striking parallelism in both series, and the presence of intergrading species, the subfamilies Pholiotoideae as defined by the senior author in 1936 as a subdivision of the Cortinariaceae should be combined with the Stropharioideae as defined by Romagnesi and the senior author as a subdivision of the family Coprinaceae into a single independent family. This manner of viewing the affinities among these major divisions of the Agaricales is not entirely new; in fact it has been expressed by Konrad & Maublanc (1924-37) who referred the genus *Nacmatoloma* to the tribus Pholiotées (containing among others such genera as *Flammula* and *Pholiota*). The senior author also expressed it by referring *Melanotus* (1936: 343) temporarily to the Cortinariaceae, Pholiotoideae. In contrast with the earlier views of the senior author and with the classification of Konrad & Maublanc we would now exclude the genera *Rozites* (near *Hebeloma* of the Cortinariaceae sensu str.) and *Crepidotus* (near *Ripartites*, Paxillaceae sensu str.) from the Pholiotoideae. We would also exclude *Phaeolepiota* which Heim and the junior author believe to be related to *Cystoderma*. For this family we propose the name Strophariaceae.

**Strophariaceae** fam. nov. Pileo viscido vel subviscido-opimo vel subudo, hygrophano vel non hygrophano; cuticula ex epicute et hypodermio consistente, epicute ex hyphis filamentosis haud regulariter palisadiformiter nec hymeniformiter dispositis; hypodermio saepissime ex hyphis latiusculis vel breviusculis, interdum parietibus crassiusculis praeditis consistente; velo annuliformi, marginali, fibrilloso atque fugaci, vel subnullo; sporis in cumulo



atrollacinis vel atrofusciis aut ferrugineo-cinnamomeis; sporis membrana duplici, levissima, apice interrupta vel attenuata poro germinativo angusto, indistincto vel lato truncato causa; lamellis nebulosis, varie adnexis (subliberis vel decurrentibus); cheilocystidiis constanter praesentibus; cystidiis prope aciem interdum differentiatas, vel pleurocystidiis refringentibus distinctis praesentibus, vel nullis; stipite variabilissimo, interdum laterali minutissimoque; carne molli, in stipite fibrosa, pigmento intercellulari saepissime praesente, interdum amara; mycelio interdum rhizomorphae albo, lignicola, terricola, fimicola, herbicola, muscicola, etc. Genus typicum *Stropharia* (Fr.) Quél. Genera cetera: (Amaurospora): *Naematoloma* Karst., *Psilocybe* (Fr.) Quél., *Deconica* (W. Smith) Karst. *Melanotus* Pat. (Ochrospora): *Pholiota* (Fr.) Quél., *Flammula* (Fr.) Quél. *Kuehneromyces* Singer & Smith, *Pleuroflammula* Singer.

*Kuehneromyces* gen. nov. Pileo glabro (vel fibrillis inconspicuis e velo nascentibus ad marginem ipsum ornato), nudo opimo-viscidulo, hygrophano, marginem versus pellucide striato in humidis, cinnamomeo-brunnescente; epicute ex hyphis subparallelis, tenuibus, hyalinis, subgelatinescentibus, jacentibus, fibuligeris efformata; subcute ex hyphis irregularibus, latiusculis, demum saepissime crassotunicatis efformata; dermatocystidiis nullis; lamellis cheilocystidiis sparsis vel numerosis ad ipsam aciem concentratis et interdum cheilocystidiis prope aciem congregatis praeditis; cystidiis aliis (typi *Flammularum*) nunquam ullis; tramate regulari, ex hyphis subintertextis vel intertextis fibuligeris hyalinis vel brunnescentibus formato; sporis membrana duplici, levissima instructis, minutis, ovoideis vel ellipsoideis, ad apicem poro lato germinativo truncatis, haud vel vix lentiformibus, melleis, in massa cinnamomeis vel brunneis (neque umbrinofusciis nec purpurascens-fusciis nec obscure lilaceis); stipite plerumque centrali, elongatoque, farcto dein cavo, velato, squaroso vel nudo, annulato vel veli reliquiis fibrilloso vel subvelato. Ad ligna, fructificationibus praecocibus. Species typica: *K. mutabilis* (Schaeff. ex Fr.) Singer & Smith (*Pholiota mutabilis* auct.). Species ceterae adhuc cognitae: *K. rostratus* Singer & Smith; *K. depauperatus* Singer & Smith; *K. vernalis* (Peck) Singer & Smith.

We name this genus for Robert Kühner who was the first author to point out that *K. mutabilis* is not a true *Pholiota*. He says (1935: 31, footnote 2) "Nous faisons, peut-être nous-même, preuve de timidité en laissant provisoirement dans le *Pholiota*, le *Ph. mutabilis*; cette espèce semble assez peu éloignée du *Ph. marginata*, mais ses spores lisses à pore germinatif tronqué l'éloignent de tous les *Galerina* que nous connaissons."

#### KEY TO SPECIES

- A. Typically northern species, growing cespitosely (sometimes solitary); color of dried pilei 9, G5 or darker ocher brown.
- B. Stipe with numerous distinct recurved scales in the portion beneath the annulus when young and fresh, darkening from the base upward in age; cheilocystidia small ( $19-29 \times 3.3-7 \mu$ ) and gill edge not heteromorphic.....*K. mutabilis*, no. 1.

- B. Stipe not at the same time squarrose and darkening from the base upward; cheilocystidia large or small, sometimes of two different types.
- C. Cheilocystidia with long, thin neck, seldom nodulose; stipe 4-12 mm. broad and not appreciably darkening with age  
*K. rostratus*, no. 2.
- C. Cheilocystidia often with short or thick neck, which in a large number is nodulose at the tip, two distinct types sometimes present; stipe 2-8 mm. broad, becoming russet to mummy brown from the base upward in age.....*K. vernalis*, no. 4.
- A. Typically southern species (Florida), with solitary habit (as far as known); color of dried pilei 9, F5 to 10, F5 (Maerz & Paul), i.e. with a more reddish tinge than in the northern forms...*K. depauperatus*, no. 3.

## DESCRIPTION OF SPECIES

1. *Kuehneromyces mutabilis* (Schaeffer ex Fr.) comb. nov.

Figures 2-3 & 8.

*Agaricus mutabilis* Schaeff. ex Fr. Syst. Myc. 1: 245. 1821

(var. *b*, *c*, *d* exclusis).

*Pholiota mutabilis* Quélet, Champ. Jura et Vosges p. 94. 1872.

*Dryophila mutabilis* Quélet, Enchir. Fung. p. 69. 1886.

Pileus 15-60 mm. broad, obtuse when young (rarely papillate), becoming campanulate or broadly conic while the margin is still strongly incurved, expanding to convex or plane or retaining a low broad abrupt umbo, the margin often remaining decurved, surface glabrous or with inconspicuous white fibrils from the veil when very young, smooth, lubricous to viscid from a more or less separable pellicle (merely moist after heavy rains have washed off the pellicle), margin closely translucent striate when moist, opaque when faded, hygrophanous, "clay color" to "ochraceous tawny" or "sayal brown" at maturity, near "Verona brown" when young, fading to near "pinkish buff" or more nearly "ochraceous buff" on disc, fading from the disc first or in a zone between disc and margin; flesh thin except in the disc, moderately soft, watery to moist, pallid, odor weak, agreeably spicy (neither radishlike nor farinaceous), taste mild or slightly unpleasant but not bitter; lamellae close to crowded (about 35 reach the stipe), broadly adnate to subdecurrent when young, later usually distinctly decurrent (more so than in other species), broad in inner third (about 5 mm. in medium sized mature caps), pallid when young, developing a dull buff tinge and eventually becoming almost "Sayal brown"; stipe 40-100 × 2-12 mm., subequal to evenly tapering toward the base, stuffed and soon becoming hollow, with an apical to subapical annulus or annular zone of fibrils, below the annulus covered almost

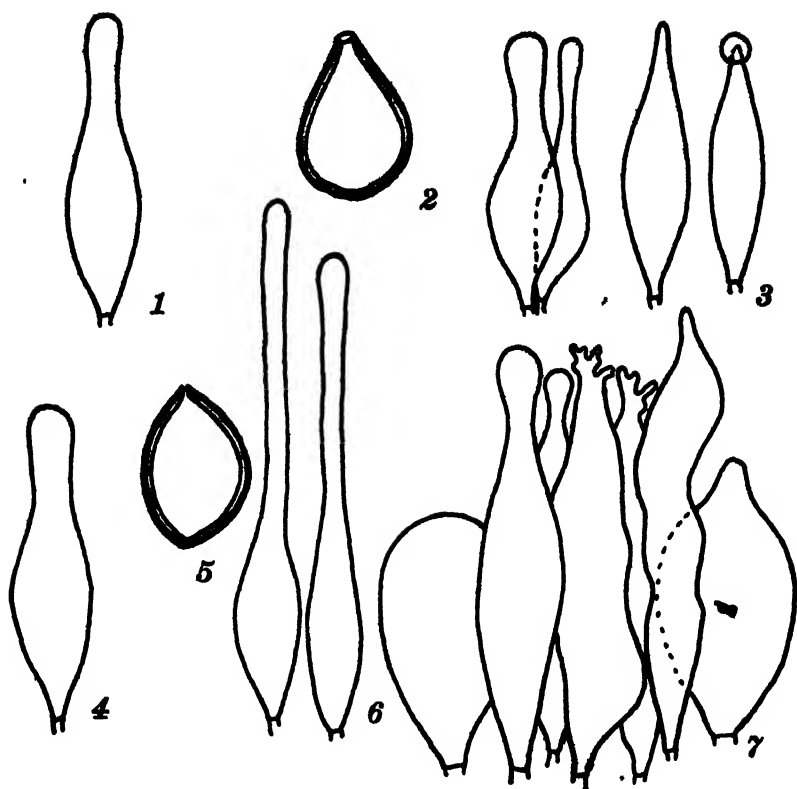


FIG. 1. *Kuehneromyces depauperatus*, a cheilocystidium from the type collection. FIGS. 2-3. *K. mutabilis*; 2, spore in approximately frontal view; the outer black line showing the exosporium, the white zone between the outer black line and the inner (thin) black line representing the endosporium. Note the broad germ pore at the apex; 3, four cheilocystidia. The two at the left represent the most common type (from American material). The central figure is from European material and represents a rare type. At the right is a cystidium from Javanese material showing the drop of mucilage at the apex. FIGS. 4-5. *Pleuroflammula Dussii*; 4, cheilocystidium (from type collection); 5, spore. The outer black line represents the exosporium, the inner black line the bright colored ring inside the endosporium; the white zone between the two black lines the endosporium. Note the narrow germ pore at the apex (from the type). FIG. 6. *Kuehneromyces rostratus*, two cheilocystidia. FIG. 7. *K. vernalis*. Five cheilocystidia in the middle representing type I; these flanked by cheilocystidia of type II (from material collected in Wyoming).

to base with distinct pallid to brownish recurved scales, lower surface of annulus also scaly in some specimens, scales sometimes indistinct in dried material, base either naked or covered by a white velutinous mycelial tomentum, somewhat silky-striate above annulus, pallid at first over all except basal portion, soon becoming brownish (near "clay color"), finally becoming dark sordid brown from base upward ("Dresden brown" to "mummy brown").

Spore print between "Verona brown" and "cinnamon" (R) or between 176 and 191 (Séguy) when quite fresh, spores under a microscope deep honey color or more fulvous-castaneous in accumulations, 6-7.5 (rarely 11)  $\times$  3.7-5.8 (6.2)  $\mu$ , smooth, ovoid, the hilar end very broadly rounded, the broadest portion near the base, in a minority more ellipsoid with thickest portion near middle, rarely somewhat subrhomboid, terete as seen in end view or up to 0.6  $\mu$  broader in front than in side view, not distinctly compressed, as seen in side view less convex on inner side, without a suprahilar depression, with a double rather thick wall and a very broad flat germ pore (hence truncate); basidia four-spored; cheilocystidia rather uniform in shape and size, abundant but gill edge not heteromorphic, 19-29  $\times$  3.3-7  $\mu$ , hyaline, ventricose to more rarely subfilamentous below, thickest in the middle or slightly below it, apex ampullaceous with a cylindric or very slightly subcapitate tip and neck cylindric, with an exudation that in KOH often enlarges to a globose appendage-like body reminiscent of the capitate cheilocystidia of many species of *Conocybe*, neck 6-11  $\times$  1.8-4  $\mu$ ; pleurocystidia not differentiated; gill trama regular, the hyphae somewhat interwoven, with brownish incrusting pigment on the walls (more pronounced in age); pileus trama of interwoven irregular hyaline hyphae which in old carpophores have somewhat thickened walls; hypoderm of similar hyphae but with heavier incrustations of pigment; epicutis consisting of closely appressed narrow filamentous subparallel hyphae forming a rather conspicuous layer at first but gelatinizing and eventually almost disappearing, all hyphae with clamp connections, non-amyloid.

The fruiting bodies occur cespitosely or densely gregarious-subcespitose, rarely isolated, and they often literally cover the stump or log upon which they grow. More rarely they are found on buried wood, on decaying boards or on beams, and prefer *Fagus*, *Populus*, *Betula*, *Alnus*, *Quercus*, etc., but occur even on *Rubus*, and more rarely on conifers. The fruiting begins in April and continues until December, depending on the region and precipitation.

MATERIAL STUDIED: Nova Scotia, Colchester Co., on *Betula lutea* in August, A. H. Smith (Wehmeyer, 783), (MICH.). New York, Adirondack Mts, September, C. H. Kauffman ("Rare in this country The first collection I know of"), (MICH.) North Carolina and Tennessee, Great Smoky Mts National Park, Mt Leconte, A. H. Smith 10478 (MICH.);



FIG 8 *Kuehneromyces mutabilis*  $\times 1$

Grassy Patch, on *Betula* June, L. R. Hesler, 12536 (FH, MICH.), Roaring Fork, A. J. Sharp 107 (FH), Indian Gap, on *Betula*, June, L. R. Hesler 11467 (FH), 13967 (MICH.); L. R. Hesler and S. L. Meyer 12701 (MICH.) Colorado, Gunnison River, among willows, August, E. Bariholomew 2655 (FH, determination doubtful) Washington, on wood of *Alnus rubra* and *Populus trichocarpa*, many collections between May and October,

*A. H. Smith*, 13426, 13709, 13741, 13620, 13918, 14265, 14534, 14721, 16163, 16252 (MICH.); Lake Quinault, on *Rubus parviflorus*, October 14, 1925, *C. H. Kauffman* (MICH.). Oregon, Rhododendron, on *Alnus*, October, *Gruber and Smith* 19540 (MICH.). Europe: The senior author has collected fresh material at many stations in the U.S.S.R., Czechoslovakia, Austria, Germany, France, Switzerland, Italy, and Spain; material is preserved in the European herbaria covering nearly every region of that continent; good material is preserved in the Hoehnel Herbarium (FH) from Austria, Niederoesterreich, Schneeberggebiet, also from the Wiener Wald, and from Aspang, etc.; also in the Burt Herbarium (FH), from Sweden, Ekero, *L. Romell*, and Uppsala, *E. A. Burt*; also in the Bucholtz Herbarium, from Russia, '44 (FH), and in the University of Michigan Herbarium from France, Humont near Plombière, Vosges, *M. Jossierand*; this material was restudied and found to be identical with the American collections. Central Asia: Altai Mts., Oirotia, *R. Singer* and *L. N. Vassilieva* (LE). Caucasus Mts., Mount Oshten in *Fagus-Abies* woods, *L. N. Vassilieva* (Herb. Cauc. Nat. Res.); Guzeripl, on dead stump of *Abies Nordmanniana*, and on stump of *Fagus orientalis*, *L. N. Vassilieva* (Herb. Cauc. Res.); Saken River valley on *Abies* trunk near timber line, and Umyrka River Valley, on stump of *Betula*, near the timber line, also Alous, in fir woods, *L. N. Vassilieva* (LE); Nenskryra Valley, Saken Valley, Khodsha Range, and Klytch Valley, *R. Singer* (W); Saken, twice on conifers, once on root of *Corylus* sp., *R. Singer* (W). Java, Tjibodas, *F. v. Hoehnel* (FH).

The most remarkable locations are those in the high mountains, near the timber line on conifers, and in the tropics in Java. Most authors indicate only frondose wood for this species, but there is no doubt that, especially in the mountains, it grows on conifer wood also. The senior author published on its occurrence on the wood of *Pinus mugho* in the Alps (Jägerkamp near Schliersee, Bavaria), in June at about 1600 m. elevation, i.e., near the timber line. This material had aberrant spores ( $9-10 \times 5-6 \mu$ ), see Zeitschr. f. Pilzk. 4: 40, no. 48, 1925. We have not been able to check on the basidia, but it is reasonable to assume that we are here dealing with a two-spored or mixed form such as we have observed in *K. vernalis*, a condition often found in the subalpine and alpine zones. However, the substratum is not correlated with spore size. Other collections on *Abies* from lower elevations had typical spores. It appears likely that here we have another example of the rule indicated by Heim and the senior author (Rev. de Myc. 1: 76. 1936) regarding the relation between spore size and altitude.

The Javanese material is abundant and in good condition. There is no doubt but that it is typical *K. mutabilis* although some speci-

mens are remarkably small. Some are of normal size, however, and we find specimens in America, from the Great Smoky Mountains for instance, which are typically smaller than those from the west and north. The locality within the Tjibodas Forest Reserve was not indicated by Hoehnel, but it may well be that these specimens were collected at a high elevation, in the "cool" or "cold" zone on Mt. Gede where tropical-alpine vegetation predominates, with many plants closely related to temperate and northern types. It should be remembered that there are several species of oak almost everywhere in that forest, and these would make logical substrata for this fungus.

Kauffman thought his collection on *Rubus* was a distinct variety of the species. After what we have seen regarding the kinds of wood *K. mutabilis* can use as a substratum, this one, even though unusual, is not altogether surprising. A careful study of the specimens failed to reveal any further distinguishing character other than the one Kauffman had emphasized, i.e., the viscid pileus. Since the viscosity in *K. mutabilis* is variable depending on the locality, the weather, and age of the fruiting body, we cannot attach any importance to it here.

*K. mutabilis*, in our opinion, is the most primitive species of the genus. As primitive characters we consider the following: the membranous well-developed and persistent annulus, the uniform small cheilocystidia which do not entirely cover the edge of the lamellae, the decurrent gills, the geographic area which is enormous as compared with that of any of the other species which must have developed from a form like *K. mutabilis* by way of local races, and finally the wide variety of hosts, which shows a complete lack of specialization beyond the limitation to woody substrata.

## 2. *Kuehneromyces rostratus* sp. nov. FIGS. 6 & 9

Pileo cinnamomeo vel argillaceo-cinnamomeo-brunneo, hygrophano, clare alutaceo in siccis, ad marginem striatulo in udis, convexo vel plano obtuso, 20-60 mm. lato; epicute ex hyphis hyalinis filamentosis subparallelis, subgelatinescens, jacentibus efformata. Lamellis pallidis vel carneo-alutaceis in juvenilibus, cinnamomeo-argillaceis vel cinnamomeis in adultis, adnexo-sinuatis vel adnato-rotundatis, saepe dente decurrentibus, mediocriter latis vel latis, confertis; sporis  $6-7.5 \times 3.7-4.8 \mu$ , eis *K. mutabili* simillimis, sed fortiter pluribus ellipsoideis quam ovoideis; basidiis tetrasporis; cheilocystidiis unius tantum typi, elongatis, apice longissimo, tenui, parte ventricosa mediana vel

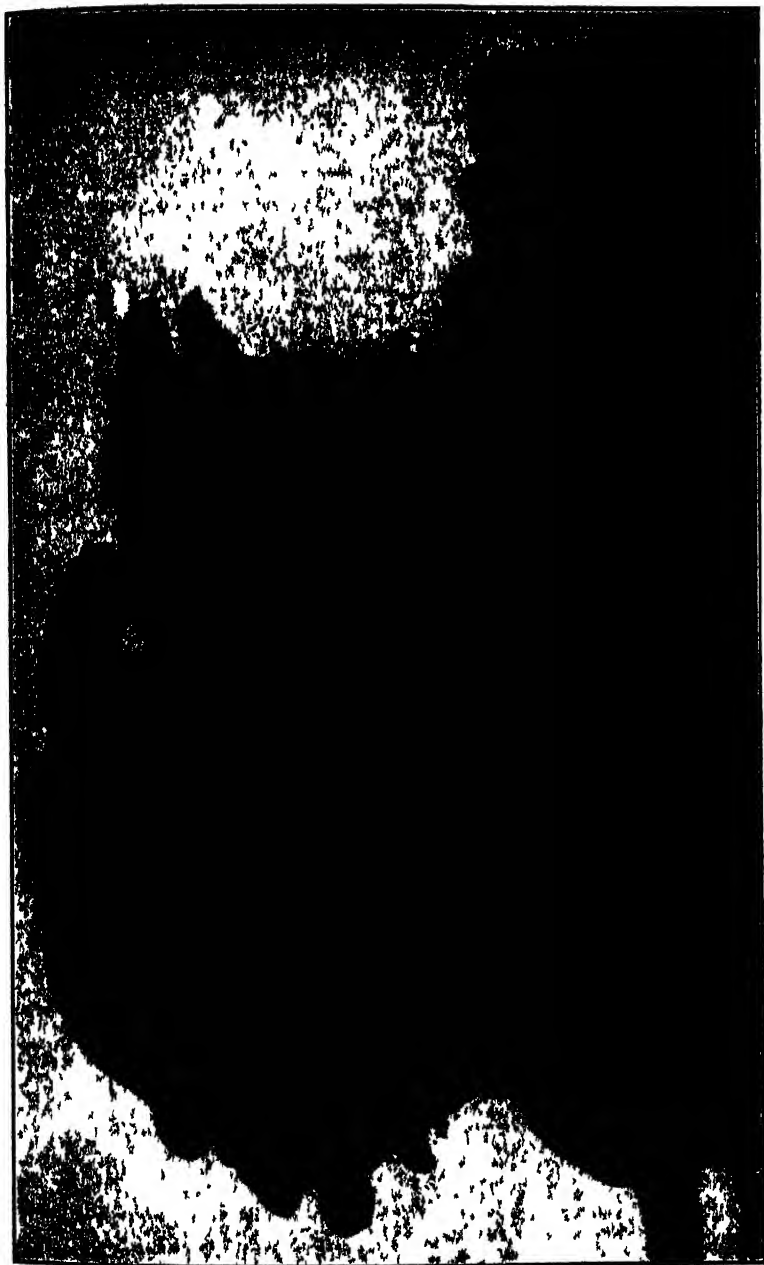


FIG 9 *Kuchneromyces rostratus*  $\times 1$



inferiore, acumine haud noduloso vel rarissime in perpaucis noduloso,  $41-62 \times 2.4-9.3 \mu$ : tramate lamellarum regulari, ex hyphis subintertextis pallidis (multis superpositis submelleis), elongatis consistente. Stipite aquose pallido vel subconcolori, quamquam pallidiore pileo sit, annulo apicali bene evoluto, angusto concolori, tenuimembranaceo, subpersistente praedito, squarruloso ad latus inferius annuli et infra annulum per nonnulla mm. ita ut in *K. mutabilis* sed haud constanter nec tam distincte quam in illa specie, sericeo vel furfuraceo supra annulum, farcto dein cavo. Carne concolori, superficiebus et plus minusve hygrophana, miti, odore nullo distincto. Ad sarmenta et ad ligna mortua arborum frondosarum fasciculariter et abundanter fructificans Maio mense in Milford, Mich., etiam in Takoma Park, Md., et Cleveland, O. Americae Borealis.—A speciebus aliis cheilocystidiorum apice elongato, plus minusve rostrato, tenui, nec non pileo obtuso, clare colorato in siccis et habitu eximie fasciculari differt.

Pileus 20–60 mm. broad, obtuse when young, soon convex to campanulate-convex, finally plane or depressed and sometimes the center perforated, rarely subumbonate, margin incurved at first, surface moist and hygrophanous, with a thin viscid or subviscid pellicle, glabrous at maturity, at first with fibrils along the margin, when young "clay color" to "Sayal brown," soon becoming "Pinkish buff" to "cinnamon," sometimes almost "avellaneous" when watersoaked, fading to warm buff or pallid and in dried specimens "warm buff" to "light buff" (darkest areas near "ochraceous buff"), or (in M. & P., 1930, pl. 9, G–5), darkest spots "Inka gold," margin even at first, later translucent striatulate; flesh concolorous with surface and more or less hygrophanous, tapering outward evenly from the disc, taste mild, odor not distinctive; lamellae adnexed-sinuate to adnate and rounded, often with a decurrent tooth, moderately broad or broader, at least broader than context is thick and usually about 5 mm. near stipe which is the broadest part, close to crowded (50–60 reach the stipe), pallid to "pinkish buff" when young, near "clay color" or "cinnamon" when mature, thin, edges even; stipe 40–90 mm. long, 4–12 mm. thick, subequal or tapering upward from a ventricose midportion, the base usually tapering, characteristically long and fleshy, interior stuffed but soon hollow, surface watery-pallid or subconcolorous, but paler than pileus, with a distinct, narrow, apical annulus which is often evanescent, somewhat squarrulose-squamulose in the manner of *K. mutabilis* (but not so conspicuously so) on underside of annulus and for a short distance downward, usually glabrescent in age, silky to furfuraceous and whitish above the annulus, at the base appressed fibrillose from the white mycelial tomentum.

Spore deposit about "snuff-brown"; spores  $6-7.5 \times 3.7-4.8 \mu$ , at maturity rather well colored but remaining pale melleous when not fully mature (color as in *Flammula lenta*), ellipsoid to ovoid

(usually the former), terete or very indistinctly lentiform, with a double wall as in *K. mutabilis*, smooth, truncate; basidia about  $21 \times 6.5-7.5 \mu$  four-spored; cheilocystidia  $41-62 \times 4.2-9.3 \mu$ , in upper third  $2-2.5$  ( $3.5$ )  $\mu$ , the apex very long in most, rostrate to rostrate-ampullaceous, the ventricose portion hyaline, tapered below ventricose portion (at or below the midportion) to a basal clamped septum, sometimes more fusoid than ventricose-rostrate-ampullaceous but even then very elongated and thin above, apex rarely nodulose and usually not forked or divided; gill edge typically heteromorphous because of very abundant cheilocystidia; pleurocystidia scattered or none; trama as in *K. mutabilis*; epicutis, hypoderm, and hyphae of context also as in *K. mutabilis*.

In woods on decaying frondose logs or debris, or on and around old sawdust piles or in areas where sawdust has been used as a fill. It has been found mostly on the wood or debris of *Quercus* or *Fagus*. It is very caespitose and fruits in May.

MATERIAL STUDIED: Maryland, Takoma Park, C. H. Kauffman (as *Pholiota* sp.) (MICH.). Ohio, Cleveland, M. B. Walters (MICH.). Michigan, Milford, A. H. Smith 15002, the type (MICH.).

The pleurocystidia are typically absent but frequently develop in areas where the hymenium has been injured. This same situation has been noted by the junior author in many species of *Psilocybe*.

### 3. *Kuehneromyces depauperatus* sp. nov. FIG. 1

Pileo, sordide melleo, hygrophano, pallide carneo-alutaceo in exsiccatis, striatulo in udis, glabro, levi, convexo, subumbonato. Lamellis olivescens-fuscis in maturis, mediocriter latis, subconfertis, adnexis vel adnatis; sporis  $6.2-6.8 \times 3-4.4 \mu$ , melleis, ellipsoideis vel ovoideis, truncatis; basidiis tetrasporis; cheilocystidiis  $27-29 \times 6-77 \mu$  ampullaceis. Stipite atrofusco, imprimis ad basin, annulo supero appresso, pallido instructo, infra annulum subfibrilloso, subaequali, cavo, cc.  $23 \times 2$  mm. Carne inodora. Ad truncum frondosum, muscosum, putridum in dumeto depressionis calcareae, solitario, Julio mense; Devil's Millhopper, Florida, U.S.A.—A *K. rostrato* colore pilei exsiccati, fructificatione solitaria aestivali et forma cheilocystidiorum differt.

Pileus about 17 mm. broad, subumbonate, smooth, convex, glabrous, translucent-striate when moist, non-striate when dry, deep sordid melleous when watersoaked, strongly hygrophanous and almost subviscid, fading to a pale pinkish buff when dry, becoming "pale yellow orange" to "light ochraceous buff" (R), or Pl. 9, F-5 (M. & P); context subconcolorous with the surfaces, watery and fleshy in pileus, somewhat tougher in the stipe; odor none; lamellae olive-fuscous when mature, medium broad (2-2.5

mm.), moderately close (about 23 reach the stipe), adnexed to adnate; stipe blackish fuscous, especially deep colored below, with a pallid fibrillose appressed apical annulus, subfibrillose below the annulus, subglabrous above it, white mycelioid at the base, subequal, narrowly hollow, about  $23 \times 2$  mm.

Spores  $6.2-6.8 \times 3-4.4 \mu$ , deep honey color, ellipsoid, some more ovoid, in frontal view often both sides more or less flattened (subrhomboid) and the diameter  $0.2-0.4 \mu$  larger than in profile, however never so distinctly lentiform as in *Deconica*, in lateral view less convex on the inner side, without suprahilar depression, with double, rather thick wall consisting of an uncolored endosporium and a colored exosporium of about equal diameter, with broad flatly truncate germ pore, smooth; basidia  $14-20 \times 5.8-6.3 \mu$ , four-spored; cheilocystidia  $27-29 \times 6-7 \mu$ , ventricose below, ampullaceous above (the neck  $2-4 \mu$  thick), sometimes slightly subcapitate sometimes cylindric to subconic above, hyaline, rather uniform in shape, size, and distribution; pleurocystidia none; trama regular, of dense, interwoven, melleous-hyaline hyphae; epicutis and hypoderm as in *K. mutabilis*; all hyphae with clamp connections.

On decaying, mossy trunk of a frondose tree in a lime-sink hammock vegetation (no conifers), solitary, fruiting in July.

MATERIAL STUDIED: Florida, Devil's Millhopper, Alachua Co., R. Singer F 2992 (FH), type.

This species seems to be closest to *K. rostratus* from which it differs in the color of the stipe, in the more carneous shade of the dried pileus, the solitary manner of growth, the smaller stature, the shorter cheilocystidia, and the fruiting season. However, we do not know whether the latter difference is constant since it is possible that *K. depauperatus*, which is rather rare, has been overlooked by collectors during other seasons. On the other hand, the Florida seasons are so different from the northern fruiting periods that we cannot but attribute a certain importance to it in this case, at least until further data show that the Florida species is not restricted to the summer rainy season.

#### 4. *Kuehneromyces vernalis* (Peck) comb. nov. FIGS. 7, 10

*Agaricus vernalis* Peck, Ann. Rep. N. Y. State Cab. 23: 91. 1872.

*Agaricus lignicola* Peck, Ann. Rep. N. Y. State Cab. 23: 91. 1872.

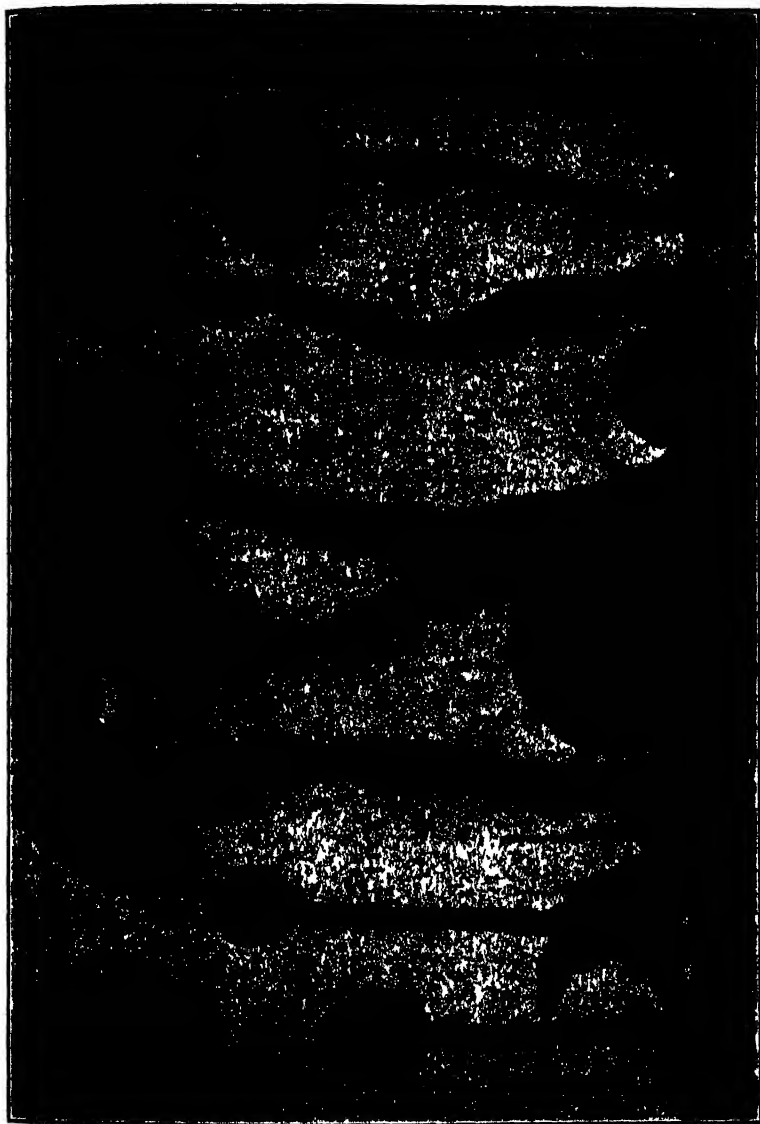


FIG. 10. *Kuehneromyces vernalis*.  $\times 1$ .

*Naucoria vernalis* Saccardo, Syll. Fung. 5: 838. 1887.

*Naucoria lignicola* Saccardo, Syll. Fung. 5: 838. 1887.

*Pholiota marginella* Peck, Ann. Rep. N. Y. State Mus. 51: 289. 1898.

*Naucoria praecox* Murrill, N. Am. Flora 10: 174. 1917.

Pileus 8–35 mm. broad, convex to obtuse when young, the margin bent inward at first, soon expanding to plane or slightly depressed around the disc, margin sometimes remaining decurved, sometimes with a conic umbo or merely papillate and with a decurved margin, surface lubricous to subviscid when moist, glabrous except for fibrils or fibrillose patches on or near the margin from the broken veil, when moist with crowded translucent striations at least along the extreme margin, hygrophanous to subhygrophanous, darkest when young (“Dresden brown,” “buckthorn brown” to “clay color” and becoming “yellow ocher,” “chamois,” “honey color” or paler before fading), often dusted “cinnamon brown” on the margin or over all from the spores, fading from the disc outward and finally changing to “maize yellow” or “warm buff” or between “warm buff” and “light buff,” sometimes showing the close marginal striations when dry as well as when moist; flesh pale yellowish to subconcolorous with surface, somewhat hygrophanous, soft and typically fragile in the pileus, moderately thick in disc but very thin toward the margin, odor slightly raphanoid to almost lacking, taste mild to somewhat mawkish, not distinctly bitter in typical form; lamellae narrow (1.5–3.5 mm. in typical specimens but sometimes up to 5 mm. broad), adnate but readily seceding at least in age, sometimes subsinuate or narrowly adnexed, if not seceding, sometimes developing a decurrent tooth, but not as decurrent as in most specimens of *K. mutabilis*, very crowded to nearly subdistant ( $\pm 30$  lamellae), arcuate to horizontal at maturity, “Sayal brown” to pale argillaceous but becoming dull rusty brown from the spores, edges entire but minutely white fimbriate (in specimens not past maturity); stipe 30–65 mm. long, 2–8 mm. in diameter, equal or tapered slightly either way, stuffed becoming hollow, sordid buff or tan to concolorous with pileus above, deeper brown below or soon becoming so (“clay color” young and fresh, soon “russet” to “mummy brown” from base upward), below the annulus (or superior fibrillose zone) naked and silky-striate longitudinally, the thin fibrillose covering paler than the ground color, with a thin submembranous to fibrillose veil which leaves a thin superior annulus or fibrillose zone, surface above this zone fibrillose-pruinose, veil sordid-pallid to sordid-brownish.

Spore deposit varying from between "cinnamon brown" and "Verona brown" to between "snuff brown" and "Brussels brown" (pl. 15-E 12 of Maerz & Paul), the differences in color probably depending on age of spore print or the moisture content when fresh; spores  $5.5-7.8$  ( $10.2$ )  $\times$  ( $3$ )  $3.3-4.8$  ( $5.5$ )  $\mu$ , most frequently  $7-7.5 \times 4-4.5 \mu$  in constantly four-spored forms, deep honey-color to melleous, fulvous-melleous in aggregations, ellipsoid to subamygdaloid in outline but a small percentage ovoid, rarely subrhomboid, either terete or very slightly lentiform (but not as compressed as in *Deconica*), in lateral view more convex on outer than on inner side, without suprahilar depression, with a double wall, consisting of a colorless endosporium and a colored exosporium, both about equally thick, smooth, with a very distinct, broadly truncate germ pore; basidia  $17-25 \times 8-7.3 \mu$ , usually all four-spored but in some populations consistently mixed with two-spored basidia (and then the spores extremely variable in size and shape); cheilocystidia of two types, usually both present, but those of type II rare at times: type I abundant to the degree of making the gill edge heteromorphous, elongate in shape, hyaline or brownish only at base, the majority with a rather broad apical portion or apex subcapitate, midportion slightly ventricose (or enlargement either slightly above or below the middle), elongated neck often flexuous or flexuous throughout, rarely forked above, subampullaceous to subfusoid, thin walled or wall rarely  $0.7 \mu$  in diameter,  $25-51 \times 6-9.3$  ( $12$ )  $\mu$ , mostly around  $45 \times 7 \mu$ , some in each mount broader than  $3.5 \mu$  in upper third: type II variable in abundance and distribution, sometimes scattered on the faces near the gill edge, typically broader than type I, vesiculose to vesiculose-clavate, balloon-shaped, up to  $15 \mu$  broad, sometimes with a short mucro, lower portion frequently brown, more rarely the whole either hyaline or brownish; subhymenium of densely and intricately interwoven hyphae characterized by a brown incrusting pigment; gill trama regular, with wart-like melleous pigment incrusting on hyphae of most carpophores; cuticle of pileus consisting of an epicutis and a hypoderm, the former consisting of a thin layer of hyaline, horizontally arranged strictly filamentous, narrow, subgelatinous to gelatinous hyphae, the hypoderm differentiated from the trama of the pileus merely by being pigmented (yellow to ocher brown) and consisting of slightly less voluminous elements, the hyphae often short and contorted (in sections creating the false impression of being intermixed with sphaerocysts), walls typically thin but sometimes appreciably thickened in age (apparently on material collected in dry weather); dermatocystidia none; all hyphae with clamp connections.

**HABITAT:** On sticks and logs, stumps and trunks, on small pieces of bark and on buried wood, often on decaying boards and beams, especially on bridges, the substratum either naked or covered by moss or earth. It is usually found on the wood of conifers (cedar, pine, larch, spruce, fir, and hemlock) but is known also from poplar and on *Fagus* and *Acer* as well as other kinds of frondose trees. In habit it is usually densely cespitose to fasciculate when at the peak of its fruiting period under very favorable conditions, but is often found in groups of only a few carpophores or even single at less favorable times. It is not as fasciculate as *K. mutabilis* or *K. rostratus*. It fruits from May until August or September, exceptionally later, and is common in the northern part of North America, rare otherwise. In North America it is known from New England west to the Pacific Coast and south to Tennessee. It is known from one station in northeastern Europe and from two in the Caucasus Mts. The distribution in general appears to be boreal and circumpolar.

**MATERIAL STUDIED** (including all aberrant forms, see the following): **Maine**, Canton Point, *J. C. Parlin*, 17138, 17115 (both FH); **Vermont**, Middlebury, *E. A. Burt* (as *Naucoria lignicola*), *Burt* Herb. (FH); **New Hampshire**, Chocorua, *W. G. Farlow* (as *Pholiota marginata*) (FH); *R. Singer* (FH); **Massachusetts**, Harvard, *Harrie Dadmun* (FH); **New York**, types of *A. vernalis*, *A. lignicola*, and *P. marginella* (N. Y. S.); **Ontario**, Lake Timagami, Paradise Bay, *T. F. R., J. W. Groves* (det. *L. O. Overholts* as *Pholiota marginella*) (FH); **Michigan**, Emerson, *A. H. Smith* 1304 (MICH.); Harbor Springs, *A. H. Smith* 1278 (MICH.); Rock River, *A. H. Smith* 33-44 (MICH.); Rees' Bog, Cheboygan Co., *A. H. Smith* 1278 (MICH.); Higgins Lake, *A. McCrea* (MICH.); Wilderness State Park, *A. H. Smith* 3282 (MICH.). **Tennessee**, Greenbrier, Sevier Co., Great Smoky Mts. National Park, *J. P. Porter* (det. *A. H. Smith*) (MICH.). **Wyoming**, Little Brooklyn Lake, *F. Arenberg* 68 (det. *A. H. Smith*) (MICH.). **Idaho**, near Lewiston, *Wm. B. Gruber* 22 (det. *A. H. Smith*) (MICH.); opposite Granite Creek, Bonner Co., *A. W. Slipp* 1498 and 1513 (det. *A. H. Smith*) (MICH.); north of Gold Creek, Bonner Co., *A. W. Slipp* 1591 (det. *A. H. Smith*) (MICH.). **Washington**, Jackson Guard Station, Olympic National Park, *A. H. Smith* 13399 (MICH.); La Push, *A. H. Smith* 12085 (MICH.); Hoh River, *A. H. Smith* 13520 (MICH.); Clallam Bay, *A. H. Smith* 13784 (MICH.); Port Ludlow, *A. H. Smith* 13869 (MICH.); **Oregon**, Mt. Hood, *Wm. B. Gruber* 3 (det. *A. H. Smith*) (MICH.). **U.S.S.R.**, Kola Peninsula, *L. A. Zinova* (det. *R. Singer*, as *Pholiota marginella* Pk.) (LE); Finno-Karelian Rep., Kivacz, *R. Singer* and *M. Freindling* (det. *R. Singer* as *Deconica acutiuscula* ined.) (LE); **Caucasus Mts.**, north slope, Czernoreczye, *L. N. Vassilieva* (det.

*R. Singer* as *Pholiota marginella*) (LE, KAZ); south slope, Babasch, Nakra Valley, *R. Singer* (as *Galera ravida*, see Beih. Bot. Centralbl. 48 (II): 530. 1931) (W or LE).

The indication of the above specimens is based on the assumption that *K. vernalis* is a very variable fungus, a fact that can be appreciated if three of Peck's own species are all considered to be synonyms of it. In some collections the annulus is distinct and the lamellae moderately broad. These are the "marginella type." Some have slender stipes and an almost fibrillose veil, the "*Naucoria* type." In those having variable spores the basidia are two- and four-spored. In some cheilocystidia of type II are abundant (f. *amara* and forms with mixed two- and four-spored basidia). In some the cheilocystidia appear capitate because of an adhering globule of viscous material—a feature very common in species of *Deconica* and one which should be observed on dried specimens revived in KOH—and in these the lamellae are crowded to close and the taste mild (f. *typica*) or bitter (f. *amara*). All these characters are intergrading, or so uncorrelated that we believe they should not be used at the species level here. Considering the strong variability of even a single collection (Chocorua, Singer), we can see no basis for recognizing *P. marginella* even as a variety of *K. vernalis*. The chief differences are a better developed veil, more obtuse pileus and broader lamellae. Judging from the type specimens of *Agaricus lignicola* and *Agaricus vernalis* both represent forma *typica*—no points of difference were found in a comparison of the types. It should be mentioned here that the European and Asiatic specimens cited have not been available for re-study in connection with this work. Notes of the senior author have been relied upon. A complete description of the Kivacz and Babasch specimens was made at the time the material was collected and reads almost word for word, including data on cheilocystidia, with that given here. The vesiculose cheilocystidia were noted as well as the others which were nodulose above. The senior author had planned to erect a new genus for these collections but still had doubts as to the exact color of the spore deposit. In his notes on one Washington collection (Port Ludlow), Smith also raised the question of the color of the spore deposit.

A number of variants appear to us to be worthy of designation



as formae. Forma *variabilis* is characterized by the mixed two- and four-spored basidia and great variation in spore size and shape. The spores measure  $6.2-9.5 \times 3.3-4 \mu$  and on the average are very narrow. This is represented by Burt's collection from Vermont. His notes, however, do not indicate even the slightest difference between this and the type form in the macroscopic characters. The material was pressed and as a result appears slightly different, as if the specimens had been more slender in all parts. In his notes Burt described the lamellae as very crowded, joined to the stem by more than half their breadth, in having a denticulate edge (as is always true of *K. vernalis* if a good lens is used), and in not reaching the margin of the pileus (an unimportant character in this genus).

Forma *amara* f. nov. A forma typica sapore amaro et pileo lato, crassiusculo, stipite fortiore, lamellisq. latiusculis differt. Little Brooklyn Lake, Wyoming, U. S. A. *F. Arenberg* 68, type.

As for the taste, we have to depend on Miss Arenberg's statement, but the generally heavier stature of these specimens and relatively broad gills may also be found to be correlated with taste and render the form easily recognized in the field. Studies of more collections are needed here. Cheilocystidia of type II are very prominent and well represented.

Forma *marginella* (Peck) comb. nov. (*Pholiota marginella* Peck, l.c.). This differs from the above form in absence of bitter taste, medium size and relatively, well developed annulus. The type and some of the Maine specimens belong here. In this form pleurocystidia of type II are poorly represented. We doubt if this difference is constant between f. *marginella* and f. *amara*, but here more collections are needed. We have seen only a few. In f. *typica* the cheilocystidia are not constant in this character.

FIG. 10 illustrates non-cespitose fruiting bodies with long stipes. Smith (1941), pl. 7, illustrated more or less clustered carpophores.

The *Naucoria vernalis* of Atkinson (1900: 154, fig. 146) is certainly not Peck's species. As for *Pholiota marginella* sensu Overholts, it is difficult to state that this is precisely *K. vernalis* f. *marginella* and nothing else. It might include *K. rostratus*, Overholts did not describe the cheilocystidia. *Naucoria lignicola*

sensu Kauffman is not correct. The specimens filed under that name appear to belong in *Galerina*.

**Pleuroflammula** Singer gen. nov. Pileo minuto admodum excentrice vel lateraliter stipitato vel subsessili et stipite minusculo vel absente a genere *Flammula* (sensu stricto) et sporarum colore poroque exiguo a *Melanoto* differt. Species typica: *P. Dussii* (Pat.) Singer (*Crepidotus Dussii* Pat.).

**Pleuroflammula Dussii** (Pat.) Singer, comb. nov. FIGS. 4-5.

*Crepidotus Dussii* Patouillard, Bull. Soc. Myc. Fr. 18: 173. 1902.

Pileus "colonial buff" to "cream color" or "ochraceous buff" to "amber brown," yellower near margin, browner toward disc, "antimony yellow" at margin, "Sudan brown" on disc in age, the covering forming a sterile narrow margin beyond the outer end of the lamellae, the surface of the pileus later glabrescent but in youth constantly fibrillose-subtomentose to tomentose, non-viscid, non-hygrophanous to subhygrophanous, smooth, convex, ellipsoid and attached at the broader side, or reniform, in larger specimens more often reniform than ellipsoid, the margin where it comes closest to the substratum always more or less attached to it and eventually becoming free, diameter 2-17 mm., most frequently between 4-10 mm.; lamellae almost "amber yellow" when seen from above in young specimens, the edge yellower than the sides which are more olive or more brownish than the edge, eventually becoming brown from the spores, comparatively broad (up to 2 mm. in the mature specimens), subclose to subdistant, adnexed, or when young also often emarginate-adnexed; spore print "Brussels brown"; stipe at apex similar in color to the margin of the pileus or the edges of the lamellae, below colored like the dorsal portion of the pileus, fibrillose-tomentose (or partially so) from the veil, later glabrescent at least over most of surface, sometimes indistinctly subannulate, always very small, curved, eccentric, later becoming sublateral and comparatively still more indistinct, up to  $2 \times 1.5$  mm.; veil initially covering lamellae, later leaving a fibrillose-subtomentose sterile margin on pileus and a fibrillose-tomentose or fibrillose-flocculose covering on the stipe, sometimes forming a narrow, small, indistinct annulus at the line where the fibrils break as the cap expands, concolorous or paler than the margin of the pileus; context yellowish, bitterish.

Spores  $6-9.3 \times 4.5-7.3 \mu$ , the larger and more mature the broader they become, tawny-ferruginous-melleous, without depression, smooth, with a double wall which is not entirely uninterrupted at the apex but the apex not truncate and there is no easily

discernible germ pore (or it is indistinct); basidia about  $26 \times 6.3-7 \mu$ , four-spored; cheilocystidia very distinct, readily visible in all stages of development, hyaline ventricose-ampullaceous,  $30-55 \times 8-10.2 \mu$ , thin-walled, the neck broad and broadly rounded above, not incrustated, very numerous and making the edge of the lamellae completely heteromorphous, occasionally some cheilocystidia found slightly back from the edge but no true pleurocystidia seen; trama of lamellae regular; cuticle of repent hyphae with pigment incrustations; often a yellow coloring matter exuded when preparations of the hymenophore are crushed in ammonia; all hyphae with clamp connections.

On limbs and twigs of dicotyledonous trees and shrubs, often seen on *Liquidambar styraciflua* and *Viburnum obovatum* in Florida, growing on fallen wood as well as on dead portions of the standing tree or shrub, often high up on the trunk or branches, solitary or gregarious, in Florida fruiting in June, July and August.

This species was described originally from the Bois des Bains Jaunes, Guadeloupe, W. I., where Duss collected it "in small quantity on a pile of indeterminable wood; color yellow, no. 411." Patouillard published it as *Crepidotus Dussii* but the spores are not those of a *Crepidotus* nor are the colors of the carpophores and the veil characteristic for any group of species or any single species ever recognized in *Crepidotus*. The spores in that genus are less fulvous and the wall is continuous at the apex; the pigments of *C. Dussii* are those of a *Flammula* rather than of any other ochrosporous agaric.

Another species of the genus *Pleuroflammula* has been described under the name of *Crepidotus flammeus* Murr. I have seen the type specimen from Virginia and a specimen from the Brogdon Hammock, Dade County, Florida. Both were determined by W. A. Murrill, and were kindly put at our disposal by Dr. Fred J. Seaver. They are very close to *Pleuroflammula Dussii*, especially macroscopically—though perhaps still more brightly colored—but differ microscopically in slightly larger spores with less developed germ pore, and, more important, in longer and narrower cheilocystidia which are capitate above, and have a yellow to brownish-melleous incrustation. The binomial *Pleuroflammula flammea* (Murr.) Sing. comb. nov. is proposed for this species.

Although not generally in favor of recognizing as separate gen-

era groups distinguished from existing genera only by their habit (here shape of the stipe) the author thinks that in the present case we have a repetition of an analogous case in the Cortinariaceae where a tropical genus with strongly eccentric to lateral, often strongly reduced stipe, *Pyrrhoglossum*, is opposed to a genus with more or less central stipe and wide distribution all over the climatic zones of all continents, *Gymnopilus*. In both cases, the pleurotoid genus is much smaller in size of the fruiting bodies as well as the number of species. The hiatus between the centrally stipitate group and the pleurotoid group in both cases, *i.e.*, between *Pyrrhoglossum* and *Gymnopilus*, and between *Pleuroflammula* and *Flammula*, is sharp and distinct enough to separate two autonomous though closely related genera. However, whereas *Pleuroflammula* and *Pyrrhoglossum* are not actually related to each other, *Pleuroflammula* is systematically analogous to *Melanotus* and certainly belongs to the same family as the latter. It represents the hitherto missing link in the two parallel series of rusty and dark-spored agarics, here combined as Strophariaceae.

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## FUNGI NOVI DENOMINATI—II

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The following fungi received from various sources appear to be new and are herewith named and described in continuation of a previous series (*Mycologia* 35: 629-637. 1943). Types of each have been deposited in the Mycological Collections of the Bureau of Plant Industry, Soils, and Agricultural Engineering, at Beltsville, Maryland.

### *Physoderma paspali* sp. nov.

*Maculis* brunneis, limitatis, amphigenis, ovalibus vel angularibus, 4-8 mm. long.; *sporangii* globosis, subglobosis vel breve cylindraceis, utrinque rotundatis, 18-33  $\times$  15-24  $\mu$ ; *episporio* 1-1.5  $\mu$  crasso.

Causing amphigenous spots on leaf blades, few to many and more numerous near juncture of blade with sheath, oval or angular to somewhat irregular and elongated, sometimes coalescing, 4-8 mm. long, chocolate brown at first (near russet of Ridgway), becoming ashen with a diffuse gray-purplish surrounding area, shredding with age, disclosing under a hand lens yellow brown masses of sporangia imbedded in the leaf tissues; *sporangia* spherical, subspherical or short cylindrical with ends rounded, smooth, golden brown, 18-33  $\times$  15-24  $\mu$ ; *wall* 1-1.5  $\mu$  thick.

In living leaf-blades of *Paspalum plicatulum* Michx. (Gramineae), Rio Piedras, Puerto Rico, *John R. Johnston* 4445, June 1912; *John A. Stevenson* 164, Oct. 1913; 6212, Feb. 1917; 6549, June 1917; 6910, March 14, 1918; *Myc. Coll.* 71415, March 15, 1918 (Type).

This fungus causes a definite, well marked spotting of the host leaves. In advanced cases the spots are frequently overgrown by *Collectotrichum graminicolum* (Ces.) G. W. Wils. Bitancourt has reported *Physoderma* sp. on *Paspalum millegrana* Schrad. in Brazil (*Inter. Bull. Plant Prot.* 12: 52 m. 1938), but without descriptive notes. Other species of *Physoderma* on grasses such as *P. searomaydis* Shaw and *P. gerhardtii* Schroet. differ in smaller sporangia and other distinctive characters.

**Ustilago speculariae** sp. nov.

Sori in capsulis; sporis nigris, opacis, levibus, globosis vel subglobosis, 21–27  $\mu$  diam.

Sori in capsules of host, causing slight distortion, upon rupture of enclosing tissues disclosing black dusty spore-mass; spores black, opaque, smooth, globose to subglobose, sometimes more irregular or elongate, 21–27  $\mu$  diameter.

In capsules of *Specularia perfoliata* (L.) A. DC. (Campanulaceae), McAlester, Pittsburg Co., Oklahoma, F. W. Pennell (10592), May 27, 1920. (Type Myc. Coll. 71423.)

This smut appears to be rare, which is perhaps in part accounted for by the fact that the clasping leaves of the host effectively conceal the aborted capsules which differ very little in size or color from normal ones. No other records have been found of the occurrence of smut species on the genus *Specularia* nor in fact on the family Campanulaceae.

**Entyloma trigonellae** sp. nov.

Sori amphigenis, maculis rotundatis vel ovalibus, minutis, 1–2 mm. diam., luteolis; sporis sparsis, globosis vel subglobosis, hyalinis vel flavescentibus, levibus, 12–16  $\mu$  diam.; episporio 1.5–2  $\mu$  crasso; conidiis non visis.

Sori in leaves, not abundant, amphigenous, forming minute spots, 1–2 mm. diameter, circular to oval, light yellow, sometimes with a greenish halo upon drying; spores sparse, spherical to subspherical, rarely ovoid, hyaline to yellowish, often with evidences of gelatinous envelope which in some cases forms papillae on the spore wall, otherwise smooth, 12–16  $\mu$  diameter, rarely 12–18  $\times$  14–15  $\mu$ ; spore wall 1.5–2  $\mu$  thick; no conidial development noted.

On living leaves of *Trigonella foenum-graecum* L. (Leguminosae), Davis, California, comm. Max W. Gardner, May 1935. (Type, Myc. Coll. 71405.)

**Asterina (Englerulaster) phoradendricola** Stevenson and Pollack sp. nov.

Coloniis amphigenis, nigris, circularibus, 1–5 mm. latis, vel confluentibus; hyphis reticulatis, brunneis, 4.5–6  $\mu$  diam.; hyphopodiis paucis, irregulariter dispersis, non-septatis, sessilibus, hemisphaericis vel breve cylindricis, late rotundatis, 7–10  $\mu$  longis, 5–7  $\mu$  latis; thyriotheciis numerosissimis, circularibus,

vel confluentibus, pulvinatis vel hemisphaericis, 60–100  $\mu$  diam.; *strato* ~~legenti~~ atro-brunneo, ex hyphis radiantibus irregulariter dehiscentibus composito; *ascis* sessilibus, late ovatis vel subaphaericis, aparaphysatis, octosporis, 40–48  $\mu$  diam.; *sporis* oblongis, valde constrictis utrinque late rotundatis, levibus, atrubrunneis, 26–32  $\times$  12–16  $\mu$ ; *cellulis* subglobosis, superiori 14–16  $\mu$  inferiori 12–14  $\mu$  latis.

*Colonies* amphigenous, black, circular to somewhat irregular, up to 5 mm. in diameter, frequently confluent and covering large areas of leaf surface; *mycelium* scanty, "cinnamon brown" to "saw brown," reticulate, meshes angular; *hyphae* straight, branching irregularly, 4.5–6  $\mu$  in diameter, with cells 15–30  $\mu$  in length; *hyphopodia* few, scattered, alternate or unilateral, sessile, hemispherical to short subcylindrical, broadly rounded above, non-septate, 7–10  $\mu$  long, 5–7  $\mu$  broad; *thyriothecia* very numerous, gregarious, often confluent in small groups, uniformly distributed over entire colony, circular to subcircular in outline, pulvinate to hemispherical, 60–100  $\mu$  diameter; *covering membrane* dark brown, composed of radiating hyphae which dehisce irregularly early in their development and are replaced by dark colored slime which encloses strands of spherical to elliptical brown cells; *basal layer* composed of radiating pale brown hyphae; *asci* one to many in a thyriothecium, sessile, thick walled, broadly ovate to spherical, 8-spored, aparaphysate, 40–48  $\mu$  diameter; *spores* oblong, broadly rounded at both ends, strongly constricted at the septa, almost equally uniseptate, smooth, finally dark brown, but long remaining hyaline, 26–32  $\times$  12–16  $\mu$ ; *cells* subglobose, upper 14–16  $\mu$  broad, lower 12–14  $\mu$ .

On living leaves of *Phoradendron flavescens* (Pursh) Nutt. (Loranthaceae), parasitic on *Carya pecan* (Marsh.) Engler & Graebn., Newnan's Lake, near Gainesville, Alachua Co., Florida, Arthur S. Rhoads, Nov. 11, 1943. (Type, Myc. Coll. no. 71427.) Fifteen additional collections were made by the same collector from September 1943 to February 1944 from the same host found parasitizing various species of *Nyssa*, *Planera*, *Prunus*, *Quercus*, and *Xanthoxylum* in Alachua, Highlands, Lake, Marion, Putnam, and Volusia Counties, Florida. (Myc. Coll. nos. 71428–71442.)

This species appears to be abundant and widespread, at least in the state of Florida, on the common American mistletoe. It is characterized by the numerous dull black amphigenous colonies which are often confluent to such an extent as to cover much of the leaf surface. The fungus is marked by the breaking down of the covering membrane of the thyriothecium into a dark colored mu-

clayey slime in which chains of spherical to elliptical brown cells occur. This character places the species in *V. Hoehnel's Englerulaster*, a genus which later workers have considered more appropriately placed as a section of *Asterina*, a decision in which we concur. The present species differs from others named on the *Loranthaceae*, including *Asterina loranthicola* Syd. and *A. loranthacearum* Rehm, by the *Englerulaster* character and by the spore sizes. *A. phoradendri* P. Henn. has been referred to *Asterinella* by Theissen, because of the absence of hyphopodia.

*Meliola condaliae* sp. nov.

*Coloniis* amphigenis, circularibus, 2-3 mm. diam.; *hyphis* 6-8  $\mu$  diam., ramis plerumque oppositis; *hyphopodiis capitatis* alternantibus, oppositis vel unilateralibus, 10-15  $\mu$  longis, 6-7  $\mu$  diam.; *hyphopodiis mucronatis* sparsis, oppositis vel unilateralibus, 15  $\mu$  longis; *peritheciis* globosis, 150-200  $\mu$  diam.; *ascis* evanidis, bisporis; *sporidiis* quadrisepatis, levibus, obtusis, 37-45  $\times$  12-18  $\mu$ ; setis rectis, opacis, usque 400  $\mu$ , basis 6-7  $\mu$  crassis, acutis vel duobus-pluribus dentatis.

*Colonies* amphigenous, but more numerous above, circular, 2-3 mm. diameter, at times coalescing to cover entire leaf surface, more rarely on smaller twigs; *mycelium* branching commonly opposite, but may be unilateral or irregular, dark brown, straight, 6-8  $\mu$  diameter (cells 15-24  $\mu$  long); *capitate hyphopodia* predominantly alternate, but some opposite and unilateral, short cylindrical to narrowly ovate, 10-15  $\mu$  long, 6-7  $\mu$  diameter, *head cell* narrowly ovate, 6-7  $\mu$  diameter; basal cell very short (2-3  $\times$  4-5  $\mu$ ); *mucronate hyphopodia* few, ampulliform, opposite or unilateral, 15  $\mu$  long, 5  $\mu$  diameter (at base); *perithecia* grouped in center of colonies, spherical, finally depressed flattened, verrucose, 150-200  $\mu$  diameter; *asci* evanescent, two-spored 45-50  $\times$  24-30  $\mu$ ; *spores* quadrisepate, deep brown, smooth, somewhat constricted at septa, obtusely rounded at both ends, 37-45  $\times$  12-18  $\mu$ ; *mycelial setae* uniformly scattered over colonies, straight or somewhat flexuous, opaque, 250-400  $\mu$  long, 6-7  $\mu$  diameter at base, acute at tips, notched or with two to several teeth up to 12  $\mu$  long. Formula under the Beeli system 31 $\frac{1}{3}$  3.4222.

On living leaves and twigs of *Condalia obovata* Hook. (Rhamnaceae), Brownsville, Cameron Co., Texas, Robert Runyon 3663 (Type), Feb. 1944; same locality, C. J. Hansel 57475, March 1944; Harlingen, Cameron Co., Texas R. Runyon 4115, Dec. 1945; Matamoros, Mexico, D. J. Smith 59943, Dec. 1945.



No previous reports have been found of any species of *Meliola* on the genus *Condalia*. On the other genera of the Rhamnaceae several species are described, but all differ in essential characters. *Meliola rhamnicola* Stevens and Tehon described from British Guiana on *Gouania* differs in its diffuse colonies, capitate hyphopodia which are alternate only, and in the smaller spores. *Meliola scutiae* Speg. described from Argentina on *Scutia* is even more divergent with opposite hyphopodia, smaller spores, undivided setae tips, larger perithecia and shorter setae.

***Phyllosticta malvavisci* sp. nov.**

*Maculis* circularibus, amphigenis, 2-4 mm. diam., cinereis, atro-brunneo-marginatis; *pycnidiis* epiphyllis, membranaceis, 100-140  $\mu$  diam.; *conidiis* hyalinis, globosis vel ovalibus, granulosis, 6-9  $\times$  5-7  $\mu$ .

*Spots* mostly circular, occasionally oval to somewhat irregular, showing on both surfaces, but more distinct above, few to many per leaf, 2-4 mm. in diameter, with narrow dark brown border and ashen-gray center above, greenish to cinereous beneath; *pycnidia* numerous, chiefly epiphyllous, scattered uniformly over the spots, membranous, 100-140 mm. diameter; *conidia* hyaline, globose to oval and long ovate, granular, 6-9  $\times$  5-7  $\mu$ .

On living leaves of *Malvaviscus drummondii* Torr. & Gray (Malvaceae), Brownsville, Texas, C. J. Hansel, Feb. 1944. (Type, Myc. Coll. 71411.)

This fungus and the leaf spot which it causes appear quite distinct from other species of *Phyllosticta* previously named on species of Malvaceae. *Ph. altheina*, *Ph. hibiscina* and *Ph. hibisci* in particular differ markedly in character of the spots produced and in the shape and dimensions of the conidia.

***Phleospora plucheae* sp. nov.**

*Pycnidiis* amphigenis, foliicolis, innatis, 120-150  $\mu$  diam.; *conidiis* hyalinis, aseptatis vel uniseptatis rectis vel curvulis, non constrictis, cylindraceutis vel subclavatis, 15-40  $\times$  5.5-7.5  $\mu$ .

*Pycnidia* few to many, amphigenous in slightly discolored irregular areas on leaves, flask shaped, 120-150  $\mu$  diameter, 120-200  $\mu$  in depth, deeply embedded in host tissue, opening by a wide pore (15-25  $\mu$ ); *conidia* cirrhone, hyaline, very light pinkish in

mass, continuous or median uniseptate, variable in shape, cylindrical to long subclavate (approaching subfusoid), with obtuse ends, straight to curved, occasionally slightly sigmoid, not constricted at the septa,  $15-40 \times 5.5-7.5 \mu$ , most commonly  $28-32 \mu$  in length.

On living leaves of *Pluchea sericea* (Nutt.) Coville (Compositae), Presidio, Texas, J. H. Russell, March 17, 1944. (Type, Myc. Coll. 71404.)

This species is rather easily overlooked because of the lack of distinctly discolored necrotic areas and by the fact that such discoloration as does occur is masked by the pubescence of the host. The fungus appears to be none the less effective in bringing about defoliation. It differs markedly in its conidia from *P. baccharidicola* Speg., the only other member of the genus reported on Compositae. *Septoria pluchaeae* Guba is distinct for the same reason.

### ***Septoria allardii* Stevenson and Pollack, sp. nov.**

*Maculis orbicularibus, ovalibus vel angularibus, amphigenis, obscure fulvis dein cinereis et fulvomarginatis, subtus obscure griseo-viridis,  $2-5 \times 3-10$  mm.; pycnidiiis dense gregariis, amphigenis, membranaceis, immersis, globosis vel globoso-depressis, ostiolatis,  $125-200 \mu$  diam.; conidiis acicularibus, hyalinis, utrinque acutiusculis, non septatis, rectis vel curvatis,  $30-45 \times 0.5 \mu$ .*

Producing circular or oval to angular leaf spots, at times coalescent to form irregular blighted areas, particularly at the tips, amphigenous, dull brown becoming ashen with definite brown borders, dull gray-green beneath,  $2-5 \times 3-10$  mm.; pycnidia amphigenous, numerous, uniformly developed over lighter colored portion of spots, membranous, globose to globose depressed, immersed in leaf tissue, ostiolate,  $125-200 \mu$  diameter; conidia acicular, hyaline, straight or somewhat curved, non-septate, acute at both ends,  $30-45 \times 0.5 \mu$ .

On living leaves of *Melanthium parviflorum* (Michx.) S. Wats. (*Veratrum parviflorum* Michx.) (Liliaceae), Elliott Knob, Augusta Co., Virginia, H. A. Allard, June 3, 1934. (Type, Myc. Coll. 71443.) The species is named in honor of H. A. Allard the collector and long connected with the botanical work of the Bureau of Plant Industry.

*Septoria sublineolata* Thuem. described from Russia on leaves of *Veratrum album* differs in many respects from our species, including epiphyllous, sparse pycnidia in elongated spots and par-

ticularly the size and shape of the conidia which are given as  $60 \times 4 \mu$ , rounded-acute at both ends. *Cylindrosporium veratrinum* Sacc. and Wint. known on several species of *Veratrum* both in this country and Europe differs in the character of the fruiting bodies as well as in the linear leaf spots and the much larger, septate conidia.

***Chaetoseptoria wellmanii* sp. nov.**

Pycnidia amphigenis, paucis in quaque macula (3-10), membranaceis, 120-170  $\mu$  diam.; ostiolis definitis, circularibus, 15-25  $\mu$  diam.; setis rectis, erectis, 3-6 septatis, 5-6  $\mu$  diam., 90-225  $\mu$  longis; conidiis hyalinis, acicularibus, rectis vel curvatis, indistincte septatis, 75-160  $\times$  2.5-4  $\mu$ .

*Pycnidia* few per spot (3-10), scattered, immersed, then partially erumpent, amphigenous, membranous, 120-170  $\mu$  diameter; *ostiole* definite, circular, 15-25  $\mu$  diameter; *ostiole setae* straight, erect, brown, sparingly septate (3-6), 5-6  $\mu$  diameter, larger at the base (up to 9  $\mu$ ), 90-225  $\mu$  long; *conidia* hyaline, acicular, straight or variously curved, obtuse to truncate at one end, the other long acute, sparingly and indistinctly septate, 75-160  $\times$  2.5-4  $\mu$ .

On living leaves of *Phaseolus vulgaris* L. (Leguminosae), near La Ceiba, El Salvador, July 1, 1943, *F. L. Wellman* 126a (Type), 128; Sacocoyo, El Salvador, July 3, 1943, 136, 137; on living leaves of *Vigna sinensis* Endl. (Leguminosae), near Sacocoyo, July 3, 1943, 1940; Zapitotan, Aug. 5, 1943, 424. The fungus is associated with circular to somewhat irregular leaf spots, commonly not over 2-6 per leaflet, and up to 1 cm. in diameter, which are occasionally coalescent, dull brown in color at first, but becoming ashen at the center with an indefinite outer dull brown area without a definite margin and no appearance of zonation.

This fungus, which clearly belongs in Tehon's previously monotypic genus *Chaetoseptoria* (Mycologia 29: 444-5. 1937), differs from his type species in a number of particulars, including amphigenous pycnidia and longer setae, but more especially in the conidia which are much longer and wider than in *C. vignae*, and are very sparingly and indistinctly septate if at all, with one end long acute. I am indebted to Dr. Tehon for an opportunity to study the type of his *C. vignae*, known at present only from Illinois.

**Ovularia lupinicola** Pollack<sup>1</sup> sp. nov.

*Maculis* amphigenis, circularibus usque irregularibus, 1–7 mm. diam., brunneis, arescendo bubalinis, margine rubro-brunneo, zona discolore circumdati; *hyphis* hypophyllis, singulis v. fasciculatis, rectis v. flexuosis, hyalinis, continuis, interdum denticulatis; *conidiis* obovatis usque globosis, continuis, hyalinis,  $16\text{--}32 \times 12\text{--}20 \mu$ .

Producing circular to irregular spots which are visible on both leaf surfaces, but more clearly above, 1–7 mm. in diameter, at first brown, finally buff at center (0.5–3 mm.) with reddish brown margin surrounded by a second buff to dark brown zone (up to 4 mm.); *fungus fruiting* usually hypophyllous, white; *conidiophores* single or in fascicles, hyaline, continuous, straight to flexuous, sometimes denticulate, bearing one or more scars where conidia have been attached,  $20\text{--}90 \times 4\text{--}8 \mu$ ; *conidia* obovoid to spherical, non-septate, hyaline,  $16\text{--}32 \times 12\text{--}20 \mu$ .

On living leaves of *Lupinus* sp. (cf. *L. polyphyllus* Lindl.) (Leguminosae), East Stanwood, Washington, R. F. Wilbur, May 19, 1944. (Type, Myc. Coll. No. 71444); *L. parviflorus* Nutt. ex Hook & Arn., Grand Mesa, Colorado, R. W. Davidson 612, July 12, 1930.

This is apparently the first record of an *Ovularia* parasitizing *Lupinus*. *Ovularia* ? *globifera* Ell. & Ev. reported on several species of *Lupinus* was transferred to *Hadrotrichum* as *H. globiferum* (Ell. & Ev.) J. J. Davis. *Ovularia sphaeroidea* Sacc. originally described on *Lotus corniculatus* in Europe is reported on *Lupinus* sp. in A. B. Seymour's Host Index of the Fungi of North America. Seymour's citation is based apparently on a record by S. M. Tracy and F. S. Earle (in E. L. Greene, *Plantae Bakerianae*, vol. 1, p. 35–36. 1901) of a specimen collected by them in Colorado in 1898 on "living leaves of *Lupinus*, Chicken Creek, 9000 feet, July 6, no. 368" and listed as *O. sphaeroidea*. A study of a portion of the original collection as issued by Baker, Earle and Tracy in their "Plants of Southern Colorado" reveals that the fungus is again *Hadrotrichum globiferum* and not an *Ovularia*.

**Septonema agaves** sp. nov.

*Caespitulis* fuscis, late effusis in plagulis ovalibus v. irregularibus, hypophyllis; *conidiophoris* levibus, badiis, septatis,  $30 \times 3\text{--}4 \mu$ ; *conidiis* 1–9-

<sup>1</sup> Flora G. Pollack, Assistant Mycologist, Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering.

septatis, brevibus, catenulatis, in septis non constrictis, rectis, cylindricis, utrinque rotundatis, verruculosis, atrobadiis,  $15-45 \times 5-6 \mu$ .

*Fungus patches* hypophyllous, dark brown, broadly effused over oval to somewhat irregular leaf spots; *conidiophores* smooth, light brown, branching, septate, up to  $30 \mu$  long,  $3-4 \mu$  diameter; *conidia* 1-9 septate, short catenulate, verrucose, deep brown, not constricted at septa, straight to slightly curved, cylindrical with both ends rounded, deep brown,  $15-45 \mu$  long,  $5-6 \mu$  diameter.

On living leaves of *Agave americana* L. (Amaryllidaceae), Lake Ilopango Road, El Salvador, F. L. Wellman 300 (Type), July 25, 1943.

This species is constantly associated with very definite oval to somewhat irregular brown leaf spots which in dried material at least are somewhat raised and with a very definite border. The conidia are in short chains which break up tardily and since constrictions are very little in evidence, it is often difficult to decide just how many conidia go to make up the longer chains, which may reach a length of  $150 \mu$ .

*Septonema agaves* appears to be distinct from *S. olivaceo-nigrum* Berk. & Br. described from Ceylon, "apparently on leaves of *Agave*" by the very definite leaf spots and by the longer non-constricted conidia.

### *Cercospora lonchocarpi* sp. nov.

*Maculis* amphigenis, subcircularibus dein irregularibus et confluentibus, fuliginosis, dein cinereis, fusco-marginatis; *mycelio* innato, castaneo, septato,  $3-4 \mu$  diam.; *conidiophoris* amphigenis, dense caespitosis, erumpentibus, brunneis,  $20-60 \mu$  longis, regularibus vel subflexuosis, stromatibus compactis enatis, continuis vel 1-2 septatis;  $20-60 \times 3-5 \mu$ ; *conidiis* obclavatis-acicularibus, subhyalinis, fumosis vel brunneis dilutis, indistincte septatis, rectis vel curvatis,  $20-75 \times 3-4 \mu$ .

*Spots* amphigenous, at first approaching circular, but soon becoming very irregular and often confluent to form large dead areas involving much of leaf surface, dull brown at first, finally light tan to ashen, with a very definite narrow dark brown circumscribing line and a yellow-brown halo 3-5 mm. wide surrounding nonconfluent spots; *mycelium* internal, regular, septate, brown,  $3-4 \mu$  diameter, forming compact subepidermal stromatic areas,  $30-60 \mu$  in diameter; *conidiophores* amphigenous, densely to very densely tufted, rupturing the epidermis, regular to subflexuous,  $20-60 \mu$

long, 3–5  $\mu$  diameter, brown, continuous or uni- to biseptate; arising from a compact tuberculate stroma, conidia obclavate-acicular, subhyaline to smoky or very light brown, indistinctly few to many septate, straight or curved, sometimes sigmoid, 20–75  $\times$  3–4  $\mu$ .

On living leaves of *Lonchocarpus nicou* (Aubl.) DC. (Leguminosae), Belem, Pará, Brazil, *W. A. Archer H-464* (Type), Feb. 14, 1945; *L. nicou*, Quista Cocha, 17 miles west of Iquitos, Peru, *Bowen S. Crandall 3217a*, June 22, 1944; *L. urucu* Killip and A. C. Sm., Belem, Pará, Brazil, *W. A. Archer H-428*, July 6, 1942; *L. chrysophyllus* Kleinh. Wauna, Koriabo River, Brit. Guiana, *W. A. Archer H-249*, July 20, 1934.

This leaf-spot inducing fungus appears to be common and widespread wherever the host genus is grown in northern South America. Dr. Archer reports it as causing considerable defoliation at times and it may well become of economic concern in large plantings.

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## SOME TAXONOMIC NOTES ON THE HIGHER FUNGI

LINDSAY S. OLIVE

(WITH 4 FIGURES)

This paper brings together a miscellaneous assortment of notes on various fungi collected by the author in different localities in this country. A few have been rarely collected and are redescribed here. A new *Tremella*, particularly interesting from the standpoint of its parasitism of another gelatinous Heterobasidiomycete, is described.

### ASCOMYCETES

NADSONIA FULVESCENS (Nads. & Kon.) Syd. (FIG. 1: nos. 1-13)

This yeast was found by the author on May 30, 1945, at Beltsville, Maryland, in the sap of *Betula nigra* L., which was exuding from a wound high up on the tree and falling onto leaves lying on the ground. This appears to be the second report of the genus *Nadsonia* outside Europe. The yeast grew in the form of conspicuous white or cream-colored patches, which were foamy in appearance. Other fungi were mixed with the yeast, but the latter was the predominant species.

The writer's identification of the organism was confirmed by Dr. J. N. Couch, who (1944) redescribed the fungus and gave its history. His is apparently the first report of *Nadsonia* in this country. Couch found the yeast at Chapel Hill, North Carolina, growing in great abundance in the slime flux of recently cut birch trees.

The Maryland collection was obtained in pure culture on corn meal agar, on which it grew well in the form of smooth, creamy white colonies, and sporulated abundantly within a few days. Microscopic observation revealed the presence of budding vegetative cells (FIG. 1: nos. 1 & 2) mixed with numerous cells in the process of ascospore formation (FIG. 1: nos. 3-13). As previously described, ascospore formation is commonly preceded by the production of a

bud at each end of a cell, the middle cell becoming the female gamete, one of the buds becoming the male gamete, and the other bud the ascus (FIG. 1: nos. 3 & 4). The male gamete then empties into the female cell and both migrate into the ascus where a single ascospore is formed (FIG. 1: nos. 5, 6, 12). According to Nadson and Konokotine (1926), the process is accompanied by a nuclear fusion and meiotic division, only one of the four resulting nuclei persisting to become the nucleus of the single ascospore. These authors reported variations of this process in which two to four nuclei might persist, with the formation of an equal number of ascospores. I have also found variations in which two to four asci appear, each with a well developed ascospore (FIG. 1: nos. 7, 8, 10, 11). Sometimes a single ascus is found to contain two or three spores (FIG. 1: nos. 9, 13). The ascospores measure 4.5–5.4  $\mu$  in diameter. These dimensions fall within the measurements given in previous descriptions of the fungus.

#### MELANOSPORA INTERNA Tehon & Stout (FIG. 1: nos. 14–18)

During the writer's recent employment with the Emergency Plant Disease Survey of the United States Department of Agriculture, a shipment of diseased peanut pods from North Carolina was received from Dr. Alton E. Prince, also in the employ of the Survey. The material was collected in October, 1944. Peanuts in two of the collections were found to contain perithecia, both outside and inside the pods, of a fungus belonging to the genus *Melanospora*. No other fungal growth was apparent to the unaided eye at that time, but when the pods were placed in a moist chamber a species of *Fusarium* began to sporulate abundantly over the diseased areas. Whenever a transfer of the *Melanospora* to agar was attempted, the *Fusarium* invariably accompanied it, or else the transfer failed to develop altogether. Single spore cultures were attempted without success. Some ascospores, which had already begun to produce germ tubes when taken from a mixed growth, discontinued development when placed alone on nutrient agar. But whenever the *Fusarium* accompanied the transfer to the same agar medium, the *Fusarium* and *Melanospora* both grew, the latter producing numerous golden yellow perithecia plainly visible



throughout the white flocculent mass of *Fusarium* hyphae and usually well above the surface of the agar.

Thus it appears that the *Melanospora* is a parasite on the *Fusarium*. In culture the latter seemed to suffer very little damage from this relationship. Nothing is known about the possible influence of the *Melanospora* in checking growth of the *Fusarium* in nature, but it does not seem likely that it would have much effect upon it. It is obvious that the *Fusarium* is the important agent in causing pod-rot in the diseased peanuts.

A careful study of the *Melanospora* revealed that it is identical with *M. interna* Tehon & Stout (1929) which was described by these authors as occurring in rotting roots of tomato. Although the fungus was then believed to be the cause of this root-rot, experiments in culturing it would probably have shown that it was growing on a *Fusarium*, which was in turn the chief cause of the disease.

The following characteristics based on observations of the fungus on peanut pods as well as in mixed cultures with *Fusarium*, are here included for the benefit of those who might encounter it when studying diseases caused by *Fusarium*. Perithecia 125–300  $\mu$  in diameter; rostrum present, not setose, or with short setae at the apex, 35–50  $\times$  34–110  $\mu$ ; asci clavate, 20–24  $\times$  53–72  $\mu$ ; ascospores 8.5–10.5  $\times$  20–23  $\mu$ , spindle-shaped, conspicuously guttulate, chocolate brown, outer wall often revealing a reticulation. In the first cultures of the fungus numerous hyphae with phialides which produced small globose phialospores were observed. These did not reappear in later cultures, but are believed to belong to the *Melanospora* life cycle. They have been reported by other investigators for various species of *Melanospora*. The characteristics given here agree very closely with those given by Tehon and Stout (1929) in

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FIG. 1. *Nadsonia fulvescens* (nos. 1–13). 1, 2, budding vegetative cells; 3–6, stages in ascospore formation; 7–11, variations in ascospore formation; 12, one-spored ascus; 13, two-spored ascus. *Melanospora interna* (nos. 14–18). 14, hypha bearing phialides and phialospores; 15, perithecium; 16, group of mature and immature asci; 17, mature eight-spored ascus; 18, *a-e*, mature ascospores showing oil droplets; *f*, surface view of ascospore showing reticulated outer wall. (All drawings  $\times$  945, except 15,  $\times$  300, and 16 and 17,  $\times$  450.)

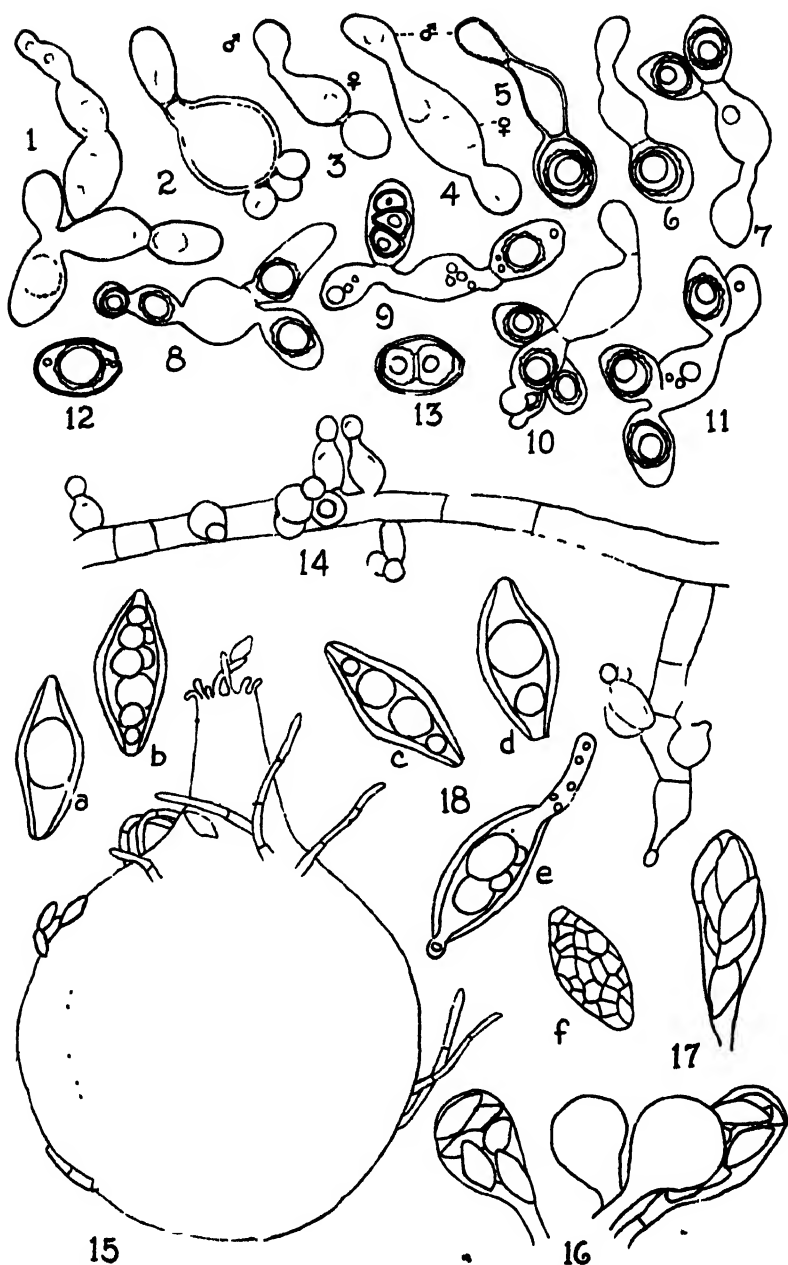


FIG. 1. 1-13, *Nadsonia fulvescens*; 14-18, *Melanospora interna*.

the original description. However, the phialides and phialospores were not reported by these authors.

Two other species of *Melanospora* which have been reported to be associated with *Fusarium* in root-rots are *M. rhizophila* Pegl. & Sacc. in decaying roots of squash and melon, and *M. asclepiadis* Zerova on underground parts of a milkweed. The latter was proved to be parasitic on *Fusarium solani*. Both species are definitely closely related to *M. interna*, but the latter differs from both in several important respects. Apparently neither *M. rhizophila* nor *M. asclepiadis* has been reported in this country.

#### BASIDIOMYCETES

*SIROBASIDIUM SANGUINEUM* Lagerh. & Pat. (FIG. 2: nos. 1-11; 4, A)

This fungus was collected during the winter of 1944-1945, in a wooded area behind the Plant Industry Station at Beltsville, Maryland. It was growing on the underside of a decorticated frondose limb lying on the ground. This appears to be the second record of its occurrence in North America. Coker (1928) found it in North Carolina. More recently Martin (1936) described a specimen of it from Australia. Originally it was described from Ecuador by Lagerheim and Patouillard (1892) and is the type species of a new family, based primarily on the seriate nature of the longitudinally or obliquely septate basidia.

The fruiting bodies of the Maryland collection grew in interrupted patches for a distance of about a foot or more. They are

FIG. 2. *Sirobasidium sanguineum* (nos. 1-11). 1, series of three basidia; 2, 3, four-celled basidia, showing oblique, vertical, and transverse septa; 4, top view of a longitudinally septate, four-celled basidium; 5-7, basidia sporulating; 8, four-celled basidium with transverse and oblique septa; 9, three-celled and two-celled basidia in a series, the three-celled one sporulating; 10, four-celled basidium, transversely septate, and two-celled basidium in a series; 11, basidiospores. *Tremelia mycophaga* var. *obscura* (nos. 12-25). 12, group of basidia and hyphae among the probasidia of *Dacrymyces* sp.; 13, branched hypha with haustorial branches applied to the *Dacrymyces* hyphae ( $\alpha$ ); 14-16, basidia; 17, basidium sporulating; 18, basidiospores, one of which is producing a secondary spore; 19-21, conidiophores producing conidia; 22, basidium and conidiophore on same hypha; 23, conidia; 24, hypha with clamp connection and haustorial branch; 25, empty basidium of the parasitized *Dacrymyces*. (All drawings  $\times 1173$ .)

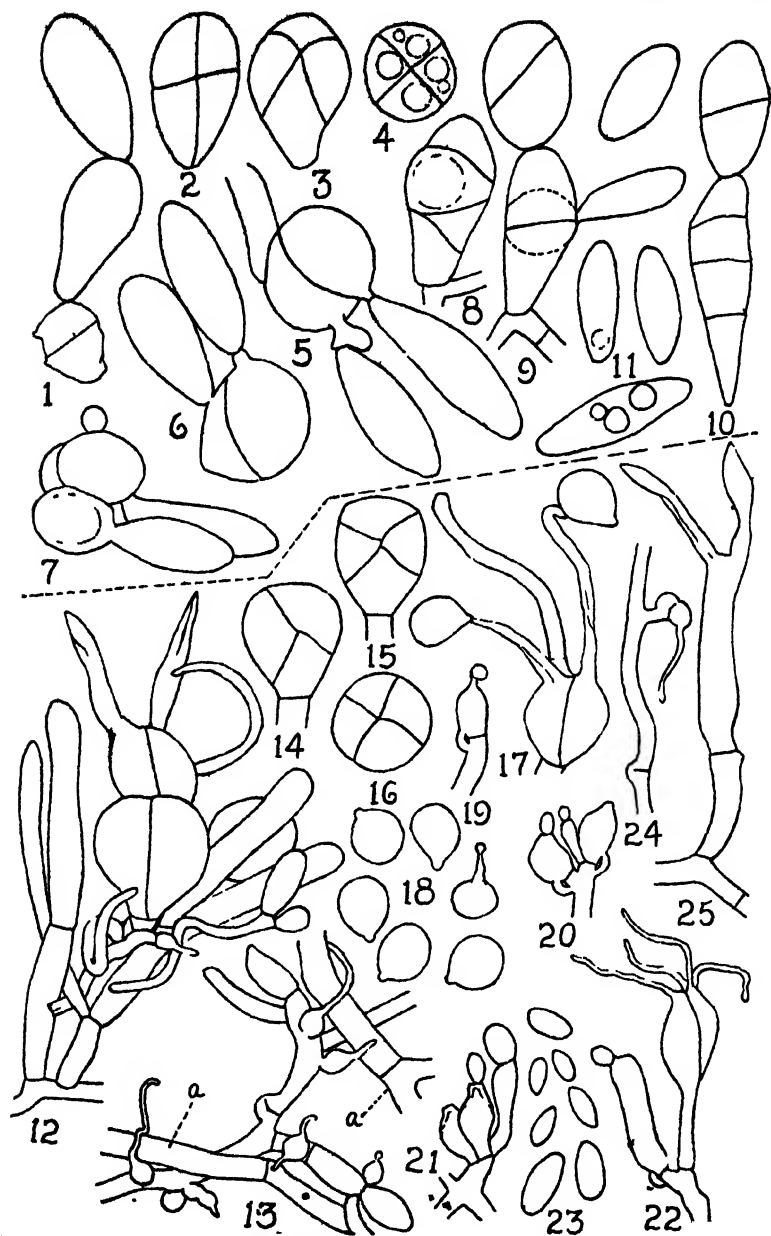


FIG. 2. 1-11, *Sirobasidium sanguineum*; 12-25, *Tremella mycophaga* var. *obscura* on *Dacrymyces minor*.

gelatinous, convoluted and gyrate, and light tan to reddish amber in color. These fructifications are conspicuous when moist but become considerably shrunken and dark reddish brown on drying. The fungus was found during the winter of 1944-1945 but was not sporulating. It was left outdoors until March 9, 1945, when it was examined and found to be sporulating abundantly.

The basidia appear singly or in chains of two to four and are longitudinally, obliquely, or transversely one- to three-septate. They range in shape from oblong or spindle-shaped to nearly globose, and measure  $11-12.5 \times 12.5-20$  (32.5)  $\mu$ . Basidiospores are mostly rather narrow-elliptic,  $5-8 \times (11)12-23.3\mu$ , and are budded out directly from the basidial cells or produced on short protrusions, which, however, do not appear to be true sterigmata. Most of these characteristics agree rather closely with those given by Lagerheim and Patouillard, Coker, and Martin.

The extreme variations in basidial types in *Sirobasidium sanguineum* are striking. The basidia are two-, three-, and four-celled, with the two-celled forms predominating and the four-celled next in abundance. The septa may be arranged longitudinally obliquely, or transversely, the oblique septation probably being most common. Four-celled basidia with all three septa transversely arranged are not uncommon. Therefore, from the standpoint of septation, the basidial forms range, in the same fungus, from the *Tremella* type to the *Auricularia* type. It is the occurrence of such Heterobasidiomycetes as the present species which tend to emphasize the phylogenetic relationships between tremellaceous and auriculariaceous forms.

**TREMELLA MYCOPHAGA** Martin var. **obscura** nov. var. (FIG. 2: nos. 12-25)

In fructificationibus *Dacrymyces* parasitica. Conidiis ellipticis,  $1.6-3.9 \times 3.3-7.8\mu$ ; basidiis subglobosis vel pyriformis,  $8-11.7 \times 9.8-15.0\mu$ ; basidiosporis  $4.2-6.5 \times 5.9-9.1\mu$ .

Parasitic within the fructifications of *Dacrymyces*. Hyphae with clamp connections and numerous haustorial branches with swollen bases which often appear to be composed of double clamp connections. Conidiophores present or absent, usually phialid-like and with basal clamp connections, sometimes occurring on the same

hyphae with basidia, conidia elliptical,  $1.6-3.9 \times 3.3-7.8 \mu$ . Basidia subglobose to pyriform, with or without basal clamp connections, mostly four-celled, frequently two-celled, the septa vertical to oblique in arrangement, measuring  $8-11.7 \times 9.8-15.0 \mu$ ; basidiospores subglobose to obovate, apiculate,  $4.2-6.5 \times 5.9-9.1 \mu$ , germinating by repetition.

Parasitic within the fructifications of *Dacrymyces minor* Peck on decorticated frondose wood and *D. deliquescens* Duby on cedar. Deciduous woods on University of Georgia campus, Athens, Georgia, October 23 and 25, 1945.

This fungus was described by me in another paper (1946) as *Tremella* sp., parasitic within the fructifications of *Dacrymyces minor* Peck. This first collection was made at Chapel Hill, North Carolina, in March, 1944. No conidiophores or conidia were found in the Chapel Hill specimens, and the fungus was then thought to be most closely allied to *T. tubercularia* Berk., which has been reported as growing from the stromatal cavities of sphaeriaceous fungi, probably as a parasite. Conidia have not been found in the latter species. Moreover, *T. tubercularia* has distinct fructifications, and there are some differences between it and the present species with regard to size of basidia and basidiospores.

*Tremella mycophaga*, however, possesses conidia and grows on the fructifications of *Aleurodiscus amorphus*, apparently as a parasite (Martin, 1940). The measurements of basidia and basidiospores vary slightly from those of the new variety, but no outstanding differences were observed. I have examined a specimen of *T. mycophaga* sent to me by Dr. Martin and have found that there is another interesting similarity between the two fungi. The hyphae of *T. mycophaga* give rise to structures resembling the characteristic haustorial branches of the new fungus.

Two important differences exist between these two fungi. *T. mycophaga* possesses distinct fructifications, while the new variety does not; that is, *T. mycophaga* var. *obscura* grows within the fructifications of *Dacrymyces* and has no distinct form of its own. Furthermore, the conidia of *T. mycophaga* are mostly subglobose, whereas those of the new variety tend to be more elliptical. It may be that these differences are sufficiently outstanding to justify the establishment of a separate species for the fungus. However, in

the light of present information, I do not believe that it should be raised above varietal rank.

**TREMELLA MESENERICA (S. F. Gray) Pers.**

The fructifications of the specimen at hand are firmly gelatinous, light yellow to bright yellow, mostly with a few flattened and sometimes hollow lobes, and measure 0.8–2 cm. in diameter. Conidia appear abundantly in the hymenium along with basidia which measure  $13.6\text{--}16.4 \times 15.5\text{--}23.3 \mu$ . Basidiospores measure  $7.8\text{--}9.7 \times 9.7\text{--}13.6$  (15.5)  $\mu$ .

The fungus in several respects resembles very closely descriptions of *T. lutescens* (Pers.) Fries. Coker (1920) suggests that *T. mesenterica* and *T. lutescens* may be the same species. At present, the writer accepts the taxonomic treatment of Martin (1944) who separates them mainly on the basis of the presence of conidia only in *T. mesenterica*. The latter has apparently not been heretofore reported in North Carolina.

Growing on corticate frondose branches, mountainous area between Old Fort and Bat Cave, North Carolina, July 31, 1945.

**DACRYMYCES PUNCTIFORMIS Neuhoff**

Numerous, small, light brownish-yellow to brown, gelatinous fructifications of the fungus were found growing on decorticated pine wood. These fructifications were at first pulvinate, but soon become disc-shaped and concave in the center, and some had an irregular, undulate margin. They are attached by a central point and are not confluent. This appears to be our smallest species of *Dacrymyces*, measuring 0.4–1.3 mm. in diameter and drying to small, almost invisible amber-colored or dark brown masses.

Clamp connections are abundant and prominent in this material. Basidia are two-pronged and typical for the group; basidiospores measure  $3.9\text{--}5.2 \times 9\text{--}13.5 \mu$ , are reniform, and become one- to three-septate. One fructification was parasitized internally by a *Tremella*-like fungus believed to be *Tremella mycophaga* var. *obscura*, but it was not sporulating.

Collected on old pine wood lying on the ground, mountainous area between Old Fort and Bat Cave, North Carolina, July 15, 1945.

This species of *Dacrymyces* is probably not uncommon in our area, but is easily overlooked because of its small size. There does not seem to be an earlier published report of its occurrence in North Carolina.

GLOEOTULASNELLA PINICOLA (Bres.) Rogers (FIG. 3: nos. 1-9; 4, B)

The fungus was found growing on the under surface of an old oak limb where it covered the bark and some old leather-fungi over a considerable area. The fructifications measure 40-100  $\mu$  in thickness and are indefinite in extent, sordid gray to purplish gray in color, gelatinous, and with an undulate or rugose surface. They dry to a thin, black or very dark gray, rough and often carbonaceous layer.

The hyphae are without clamp connections, no gloeocystidia are present, and basidia are mostly in fascicles, forming a rather compact hymenium. They are clavate or clavate-capitate, and measure  $8.1-9.6 \times 10.4-17.1 \mu$ . The epibasidia are two to four in number, usually four, and measure  $6.3-7.2 \times 8.1-12.6 \mu$ . The basidiospores are mostly subglobose to obovate,  $4.5-5.9 \times 5.9-8.4 \mu$  and germinate by repetition.

Collected on *Quercus rubra*, Raleigh, North Carolina, December 10, 1944.

The writer is grateful to Dr. G. W. Martin for his identification of the fungus. The above measurements compare very well with those given by both Martin (1944) and Rogers (1933). Martin emphasizes the extreme variability of the fungus in nature. This is true with respect to color, texture, and thickness of the fructifications, as well as from the standpoint of microscopic characters. This is apparently the first report of the species from the Southeastern States.

NIDULARIA CASTANEA Ell. & Ev. (FIG. 3: nos. 10-23; 4, C and D)  
*Granularia castanea* (Ell. & Ev.) White.

This interesting fungus has until now been known only from its original locality. It was found growing at Newfield, New Jersey, by Ellis in 1883. White (1902) examined the type specimen and described it as *Granularia castanea*. I am following the treatment



of Coker and Couch (1928) who prefer to retain the generic name *Nidularia* Fries. They state: "Miss White uses the name *Granularia* Roth, but as Fries and Tulasne use *Nidularia* and the latter clearly defines the genus as now used we retain the latter name. Both names antedate Persoon."

The fungus was found growing in scattered groups on the under-surface of an old piece of rotting canvas along with *Helicosporium aureum* (Cda.) Linder. The latter fungus was identified by Dr. W. W. Diehl. The description of the present collection of *Nidularia castanea* follows:

Peridia small, 0.5–1 mm. in diameter, white, the peridial membrane very thin, almost arachnoid, eventually disappearing and leaving the peridioles bare; peridioles 5–50 in a peridium, chocolate brown, discoid, measuring 0.21–0.42 mm. in diameter, without a funiculus, surrounded by a glutinous substance.

Numerous clamp connections were observed on hyphae of the fungus. Relatively large gelatinizing cells are found in the walls of the peridioles. The hymenium is composed of probasidia, basidia, and a number of variable sterile structures; the latter varying from slender paraphysis-like structures with or without an enlarged, thick-walled base to enlarged thick-walled cells which may represent metamorphosed basidia and whose measurements are  $6.3\text{--}10.4 \times 9.5\text{--}13.5 \mu$ , some probably smaller and easily confused with the larger basidiospores. The basidia are clavate, usually have a slender stalk, sometimes have a gelatinous sheath at the base, and are mostly four-spored, but sometimes two- or three-spored. They measure  $4.5\text{--}7.2 \times 11.7\text{--}26.1 \mu$ . The sterigmata are short or apparently obsolete to conspicuously elongated, and the basidiospores are rather broadly elliptical or obovate, hyaline, thick-walled, smooth, and measure  $4.1\text{--}6.5 \times 5.9\text{--}8.2 \mu$ .

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FIG. 3. *Gloeotulasnella pinicola* (nos. 1–9). 1, upright hymenial hyphae bearing basidium and probasidia; 2, 3, probasidia; 4, basidium producing epibasidia; 5, basidium with germinating epibasidia; 6, 7, groups of basidia in various stages of development; 8, epibasidium producing a basidiospore; 9, basidiospores, one of which is germinating by repetition. *Nidularia castanea* (nos. 10–23). 10, group of probasidia, basidia, and slender paraphyses; 11–15, basidia sporulating, those in 14 and 15 with gelatinous sheaths at their bases; 16, thick-walled cells produced in the hymenium; 17, thick walled, long-stalked element presumably produced in the hymenium; 18, 19, parts of the structures with enlarged, thick-walled bases; 20, basidiospores; 21, hyphal fusion; 22, thick-walled gelatinizing cells from the walls of a peridiole; 23, hypha with clamp connections. (All drawings  $\times 945$ .)

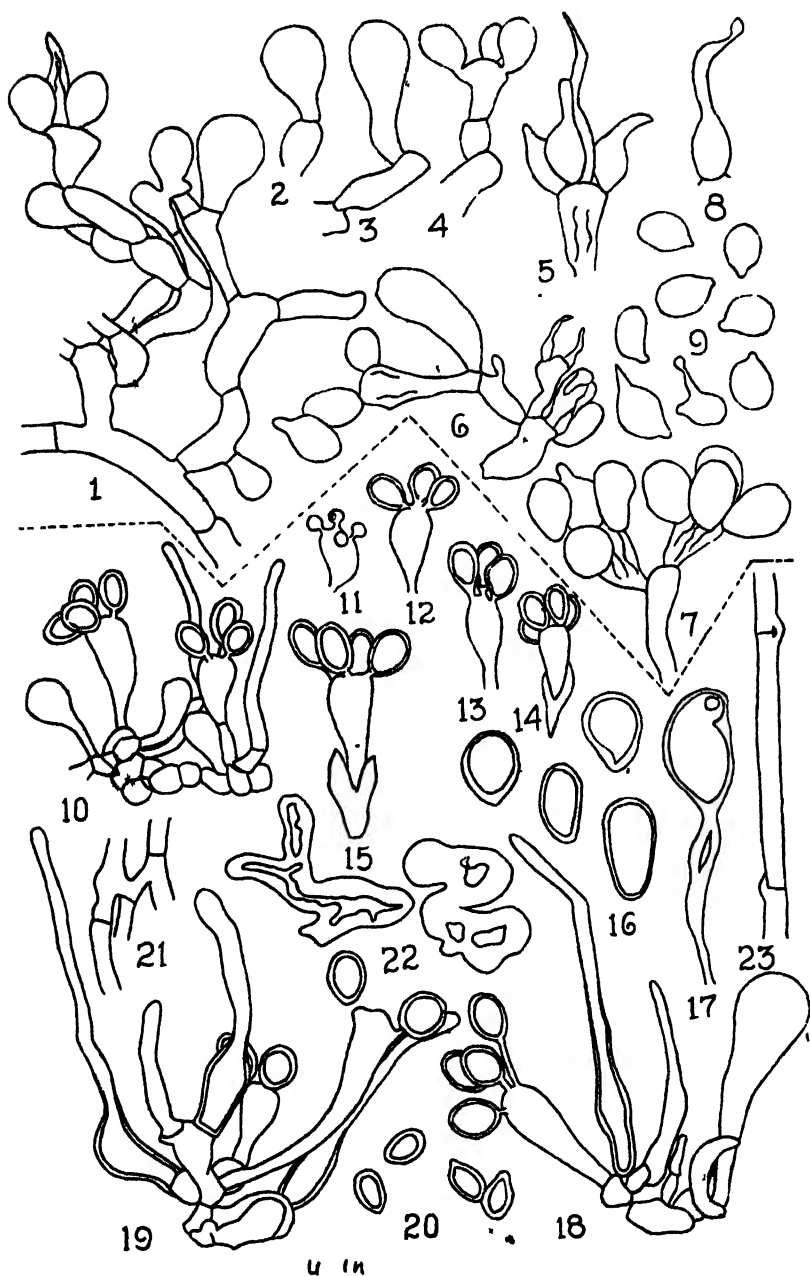


FIG. 3. 1-9, *Gloeotulasnella pinicola*; 10-23, *Nidularia castanea*.

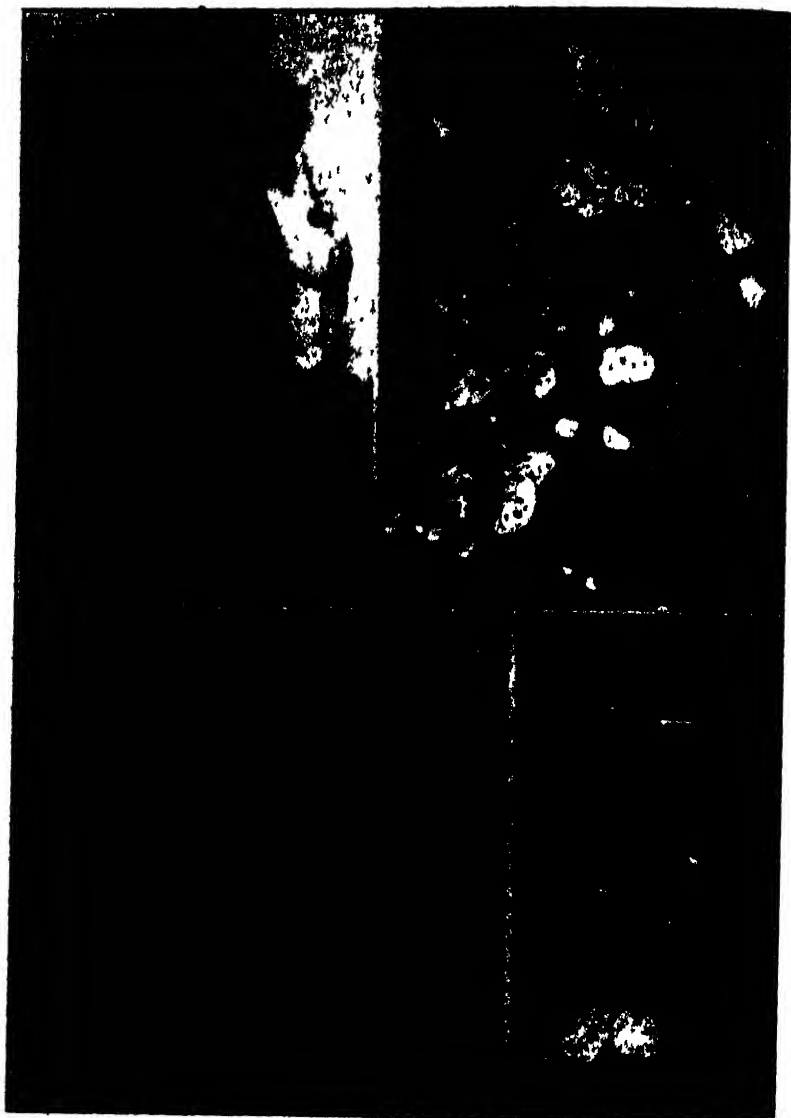


FIG. 4. Photomicrographs. A, *Sirobasidium sanguineum* on piece of dead wood ( $\times 5$ ); B, *Gloeotulasnella pinicola* on bark of dead oak limb ( $\times 10$ ); C, D, *Nidularia castanea*, peridia on rotting canvas ( $\times 8$ ). Note the group of naked peridioles, following the disintegration of the thin peridial wall, in D (arrow).

White gives the spore measurements as  $3-6 \times 4-7 \mu$ ; whereas Coker and Couch find them to be  $4.5-7 \times 6-9 \mu$ . *N. castanea* is easily distinguished from *N. pulvinata* (Schw.) Kuntze, by the much smaller peridia and peridioles of the former. According to Coker and Couch, it is the only other species found in our area.

Collected near the Plant Industry Station, Beltsville, Maryland, May 22, 1945.

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# PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI XLII. GORGONICEPS

FRED J. SEAVER

(WITH 2 FIGURES)

The genus *Gorgoniceps* comprises a group of inoperculate cup-fungi in which the apothecia are usually so minute that they are often overlooked by the collector. They are usually rather bright colored or, at least, not very dark, and usually soft and waxy.

Although the apothecia are minute, the spores are often unusually large and resemble those of the genus *Godronia*. However, in *Gorgoniceps* the apothecia are always superficial whereas in *Godronia* they are erumpent. A number of species have been encountered and doubtless there are many more. Those that are known to the writer are listed here.

GORGONICEPS Karst. Myc. Fenn. 1: 15. 1871.

*Belonopsis* Sacc. Syll. Fung. 16: 752. 1902.

Apothecia sessile or short-stipitate, soft and waxy, yellowish or ochraceous, turbinate to subdiscoid or scutellate, seldom exceeding 2-3 mm. in diameter and often less than 1 mm.; asci cylindric to clavate, typically eight-spored; spores elongate, filiform, fusiform, or vermiform, usually becoming multiseptate, hyaline; paraphyses filiform, enlarged above and often branched.

Type species, *Gorgoniceps aridula* Karst.

The genus *Apostemidium* which is usually treated with the Geoglossaceae is close to the present genus and some regard them as synonymous. Durand, however, treated them as distinct and retains the former with the Geoglossaceae because of its general resemblance to *Vibrissea*.

Spores filiform; occurring on bark and cones or leaves of conifers.

Spores  $2.5-3 \times 65 \mu$ , 16-20-septate .....1. *G. aridula*.

Spores  $2 \times 35-40 \mu$ , 3-4-septate .....2. *G. Pumilionis*.

Spores  $1 \times 12-15 \mu$ , on leaves of *Pinus* .....3. *G. ontariensis*.

Spores cylindric fusoid or clavate, occurring on rotten deciduous wood, palm stems and bamboo.

Spores  $3-4 \times 30-37 \mu$  ..... 4. *G. iowensis*.

Spores  $5-7 \times 40-45 \mu$  ..... 5. *G. confluens*.

Spores  $9-10 \times 50-55 \mu$  ..... 6. *G. jamaicensis*.

1. *GORGONICEPS ARIDULA* Karst. Myc. Fenn. 1: 185. 1871.

Apothecia gregarious or scattered, sessile or contracted into a very short, stem-like base, bluish-hyaline, when dry pale brownish, reaching a diameter of 0.3–0.8 mm.; hymenium bluish-hyaline or pallid, plane or convex; asci clavate, attenuated above and tapering below into a stem-like base, reaching a length of 100–125  $\mu$  and a diameter of 15  $\mu$ ; spores fasciculæte, filiform, straight or curved, becoming septate (the number difficult to determine but apparently 16 to 20), reaching a length of 65  $\mu$  and a diameter of 2.5–3  $\mu$ ; paraphyses filiform about 2  $\mu$  in diameter.

On coniferous bark and scales of *Pinus pungens*.

TYPE LOCALITY: Europe.

DISTRIBUTION: Pennsylvania; also in Europe.

ILLUSTRATIONS: E. & P. Nat.-Pfl. 1<sup>1</sup>: 208, f. 163 A; Rab. Krypt.-Fl. 1<sup>3</sup>: 652, f. 1–5.

The only American specimen of this species seen is one collected by Dr. L. O. Overholts and P. Spaulding (No. 10795) in Pennsylvania. The plants are minute and the species is probably more common than indicated by the material at hand.

2. *GORGONICEPS PUMILIONIS* Rehm in Rab. Krypt.-Fl. 1<sup>3</sup>: 692. 1896.

*Pezicula Pumilionis* Rehm, Hedwigia 21: 115. 1882.

*Dermatella Pumilionis* Sacc. Syll. Fung. 8: 490. 1889.

Apothecia gregarious, sessile or contracted into a short, stem-like base, at first rounded, expanding and becoming scutellate, pale cinereous, becoming brownish-yellow, reaching a diameter of 0.1–0.3 mm.; asci clavate, reaching a length of 75–80  $\mu$  and a diameter of 6–7  $\mu$ , attenuated above and gradually tapering below into a stem-like base; spores filiform, becoming septate (the number of septa usually 3 or 4),  $2-2.5 \times 35-40 \mu$ ; paraphyses filiform, about 1.5  $\mu$  in diameter.

On cones of conifers.

TYPE LOCALITY: Europe.

DISTRIBUTION: Colorado; also in Europe.

EXSICCATI: Clements, Crypt. Form. Colo. 290.

The only American specimen of this species seen is the Clements specimen referred to above on scales of *Picea* sp.

3. *GORGONICEPS ONTARIENSIS* (Rehm) Hoehnel, Mitt. Inst. Hochs. Wien 3: 106. 1926.

*Pezizella ontariensis* Rehm, Ann. Myc. 11: 167: 1913.

Apothecia scattered, sessile, at first globose expanding becoming cup-shaped, finally discoid, contracted at the base, 0.5–1.5 mm. in diameter, pale yellowish-white, externally floccose; hymenium plane or nearly so, pale rose-colored; asci clavate, reaching a length of  $45\ \mu$  and a diameter of  $6\text{--}7\ \mu$ , eight-spored; spores filiform, overlapping in the ascus  $1 \times 12\text{--}15\ \mu$ ; paraphyses filiform, hyaline,  $1.5\ \mu$  in diameter below, enlarged above to  $3\ \mu$ .

On needles of *Pinus resinosa*.

TYPE LOCALITY: East Shore of Lake Huron, Ontario.

DISTRIBUTION: Known only from the type locality.

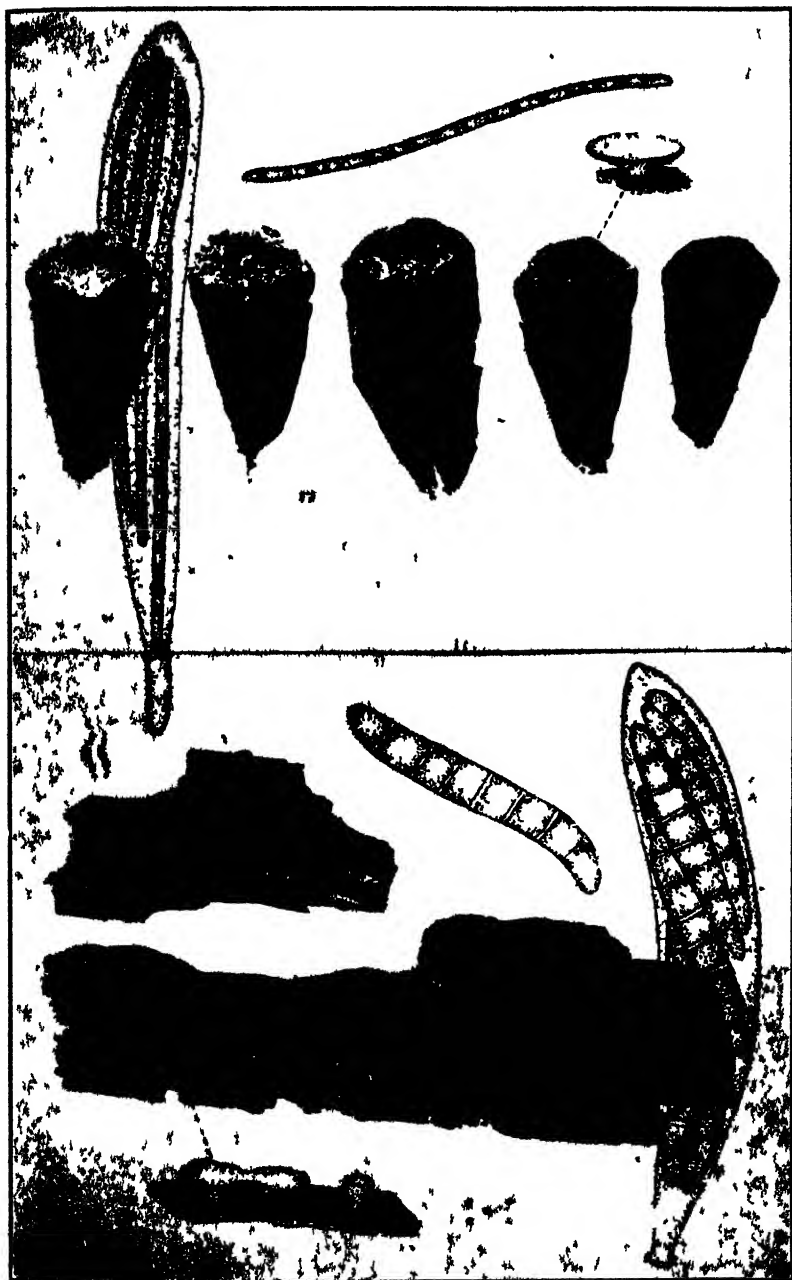
EXSICCATI: Rehm, Ascom. 2030 (apparently part of type material).

4. *GORGONICEPS IOWENSIS* Rehm, Ann. Myc. 4: 338. 1906.

Apothecia scattered, at first subglobose, sessile or contracted into a very short stem, expanding and becoming patellate, whitish, with a slight grayish-green tint when dry, pale-brownish, reaching a diameter of 0.2–0.5 mm.; asci clavate, reaching a length of  $80\text{--}100\ \mu$  and a diameter of  $10\text{--}12\ \mu$ ; spores subcylindric or clavate, straight or curved, becoming 7-septate, hyaline,  $3\text{--}4 \times 30\text{--}37\ \mu$ ; paraphyses filiform, slightly enlarged above.

Upper figure. *Gorgoniceps aridula*. Photographs of several scales from cones of *Pinus pungens* collected in Pennsylvania by L. O. Overholts. At the left, drawing of an ascus with spores. Above, drawing of one apothecium enlarged; also one spore isolated.

Lower figure. *Gorgoniceps confluens*. Photographs of rotten wood bearing apothecia, with drawings of three apothecia below, much enlarged. At the right, an ascus with spores. Above, one spore isolated. Photographed from type material collected in Bermuda by Stewardson Brown, N. L. Britton and F. J. Seaver in the winter of 1912.



Species of *Gorgoniceps*



On rotten wood.

TYPE LOCALITY: Mt. Pleasant, Iowa.

DISTRIBUTION: New York and Iowa.

ILLUSTRATION: Bull. Lab. Nat. Hist. State Univ. Iowa 6: *pl.* 26, f. 2.

5. *GORGONICEPS CONFLUENS* Seaver & Waterston, *Mycologia* 32: 399. 1940.

Apothecia gregarious, occasionally crowded and several fusing together, sessile or contracted into a very short, stem-like base, whitish or bluish-white, remaining light-colored or becoming darker when dried, reaching a diameter of 0.5 mm., soft and waxy; hymenium plane or slightly convex, similar in color to the outside of the apothecium; asci broad-clavate, with a very short, stem-like base, attenuated at the apex, reaching a length of 100  $\mu$  and a diameter of 14  $\mu$ , eight-spored; spores bunched together and overlapping, cylindric, fusoid or subclavate, straight or more often curved or double curved, becoming seven-septate,  $5-7 \times 40-45 \mu$ ; paraphyses filiform, about 2  $\mu$  in diameter.

On rotten wood and on palm stems.

TYPE LOCALITY: Bermuda.

DISTRIBUTION: Known only from the type locality.

Type collected in Bermuda by Stewardson Brown, N. L. Britton and Fred J. Seaver (No. 1487) Nov. 29-Dec. 14, 1912. This is very similar to *G. iowensis* Rehm, which was described from material collected by the author in Iowa. The spores of the Bermuda specimens seem to be larger. Also collected in Paget Marsh on stems of native palm, Seaver & Waterston 62.

6. *Gorgoniceps jamaicensis* Seaver, sp. nov.

Apotheciis gregariis vel confluentibus, sessilibus vel subsessilibus, subcitrinis, 0.5 mm. diam.; hymenium planum vel concavum; ascis clavatis, 8-sporis,  $20 \times 140 \mu$ ; sporis fasciculatis, subcylindraceis, vel clavatis,  $9-10 \times 50-55 \mu$ , 7-septatis; paraphysibus filiformibus, 2  $\mu$  diam.

Apothecia gregarious or crowded, occasionally several coalescing, sessile or nearly so, becoming patellate, in dried specimens pale yellowish-amber, semitranslucent, reaching a diameter of 0.5 mm.; hymenium plane or slightly concave; asci clavate, eight-spored, reaching a length of 140  $\mu$  and a diameter of 20  $\mu$ , tapering below

# THE GENUS STOMIOPELTIS (HEMISPHAERIACEAE)<sup>1</sup>

E. S. LUTTRELL

(WITH 21 FIGURES)

In the vicinity of Experiment, Georgia, in 1942 a hemisphaeriaceous fungus was found causing an olive blotch of the canes of *Arundinaria tecta* (Walt.) Muhl. This fungus appeared to be an undescribed species of *Stomiopeltis*. In order to determine its position in the genus a study was made of all previously described species of *Stomiopeltis*. This study has resulted in a revision of the genus.

## TAXONOMY

The genus *Stomiopeltis* was established by Theissen (1914) to receive a single species, *S. aspersa* (Berk.) Theiss., which was transferred to the Hemisphaeriaceae from the genus *Calothyrium* in the Microthyriaceae. *Stomiopeltis*, along with two related genera erected at the same time, *Stomiopeltella* and *Plochmopeltella*, was placed in a new subfamily of the Hemisphaeriaceae, the Plochmopeltineae. The Plochmopeltineae were distinguished from the two existing subfamilies of the Hemisphaeriaceae, the Dictyopeltineae and the Thrausmopeltineae, by the presence of a dark-colored superficial mycelium and by the structure of the shield of the ascarp. This was described as being "hyphis maeandrice sinuosis

<sup>1</sup> Paper No. 150, Journal Series, Georgia Experiment Station.

I am grateful to Dr. David H. Linder for his advice during the course of this study and in the preparation of the manuscript, to Dr. John A. Stevenson and Dr. B. B. Higgins for their criticisms of the manuscript, to Dr. Rolf Singer for checking the Latin diagnosis, and to Dr. David H. Linder, Earlow Herbarium, Harvard University, Dr. Fred J. Seaver, New York Botanical Garden, Dr. John A. Stevenson, Bureau of Plant Industry, Dr. Neil E. Stevens, University of Illinois, Dr. A. A. Bitancourt, Instituto Biológico, São Paulo, Brazil, and Dr. E. J. Salisbury, Royal Botanic Garden, Kew, England, for their kindness in furnishing specimens from the herbaria of their respective institutions.

contexta" (Theissen 1914) or "maeandrisch plectenchymatische" (Theissen and Sydow 1917). *Stomiopeltis* was distinguished from other genera of the Plochmopeltineae by the presence of paraphyses. Since that time the following six species of *Stomiopeltis* have been described: *S. rubi* (Fckl.) Petr. (Petrak 1923), *S. cassiae* Mendoza (Stevens and Manter, 1925), *S. heteromeris* Syd. (Sydow 1927), *S. philippinensis* Syd. (Sydow and Petrak, 1931), *S. chilensis* Syd. (Sydow 1932), and *S. citri* Bitan. (Bitancourt 1934).

As Bitancourt (1934) has pointed out, the vagueness of the description of shield structure in *Stomiopeltis* and the lack of illustration of it have resulted in different interpretations of the genus by later authors and in their inclusion of fungi of diverse structure in *Stomiopeltis*. Examination of material of all species of *Stomiopeltis*, with the exception of *S. philippinensis*, has shown that the species may be divided into two distinct groups. In the first group, consisting of *S. heteromeris*, *S. chilensis*, and *S. philippinensis*, the shield of the ascocarp is radiate in structure (FIG. 1, 2, 3). At maturity the radiate structure of the shield is somewhat obscured by the curving and twisting of the radiating hyphae and by the irregular lobing of their cells. The tissue thus formed might well be termed "maeandrisch plectenchymatische." Nevertheless, the ascocarps are fundamentally radiate; and, for this reason, the species in this group cannot be retained in the Hemisphaeriaceae. Instead, they must be placed in the Microthyriaceae where their position can be determined only by a review of that family.

In the second group, comprising *S. aspersa*, *S. rubi*, *S. cassiae*, and *S. citri*, the shield is non-radiate. It is composed of a pseudoparenchyma of inordinately arranged, sinuous, irregularly lobed cells (FIG. 4, 9, 10, 11). These species are correctly placed in the Hemisphaeriaceae where they form a distinct group deserving generic recognition. The name *Stomiopeltis* is reserved for this group since it includes the species, *S. aspersa*, which Theissen designated as the type of the genus. For reasons considered below under the individual species, *Stomiopeltella suttoniae* Mendoza is transferred to *Stomiopeltis*, the variety *minor* of *S. citri* is raised to specific rank, and the fungus on *Arundinaria* is added to the genus as a new species.

STOMIOPELTIS Theissen; Broteria 12: 73-96. 1914, emend.

Mycelium present at maturity, brown, superficial, reticulated; ascocarps superficial, dimidiate-scutate, ostiolate, uni- or polyloculate, shield composed of a pseudoparenchyma of inordinately arranged, sinuous, irregularly lobed cells, becoming plectenchymatous at the margin and merging with the surrounding mycelial net; asci grouped in locules, more or less prostrate, radiately arranged, their bases lying at the periphery of the locule, their apices converging toward the ostiole, pseudoparaphysate; ascus wall thick, composed of two layers; ascospores hyalodidymous.

Type: *Stomiopeltis aspersa* Theiss.

Since no physiological studies have been made on any species of *Stomiopeltis*, it seems best to classify the species strictly upon the basis of comparative morphology and not to recognize as distinct species or varieties morphologically similar forms which occur on different hosts. The majority of the species are rather uniform in structure. In the separation of species variations in dimensions of ascocarps, asci, and ascospores must, therefore, be relied upon. Unfortunately, most of the species are known only from single type collections in which the material is often too scanty or too poorly developed to permit an adequate number of measurements of asci and ascospores. Consequently, it is difficult to define the species satisfactorily; and any arrangement of them in the genus is necessarily tentative.

#### KEY TO SPECIES OF STOMIOPELTIS

1. Ascocarps containing 2-16 locules.....7. *S. polyloculatis*
1. Ascocarps containing a single locule.....2
2. Ascocarps over 200  $\mu$  in diameter, with a distinct, flat, plectenchymatous border.....4. *S. suttoniae*
2. Ascocarps less than 200  $\mu$  in diameter, lacking a distinct border.....3
3. Asci oblong to ovoid, less than 30  $\mu$  in length.....4
3. Asci cylindrical to clavate, more than 30  $\mu$  in length.....5
4. Ascocarps 64-136  $\mu$  in diameter, ascospores hyaline.....2. *S. rubi*
4. Ascocarps 50-80  $\mu$  in diameter, ascospores hyaline to yellowish  
6. *S. minor*
5. Ascocarps less than 140  $\mu$  in diameter.....3. *S. cassiae*
5. Ascocarps more than 140  $\mu$  in diameter.....6

6. Ascospores  $6-11 \times 2-4 \mu$  ..... 5. *S. citri*  
 6. Ascospores  $8-9 \times 2-2.7 \mu$  ..... 1. *S. aspersa*

1. *STOMIOPELTIS ASPERSA* (Berk.) Thiess., Broteria 12: 73-96.  
 1914.

*Asterina aspersa* Berk., Decad. No. 476.

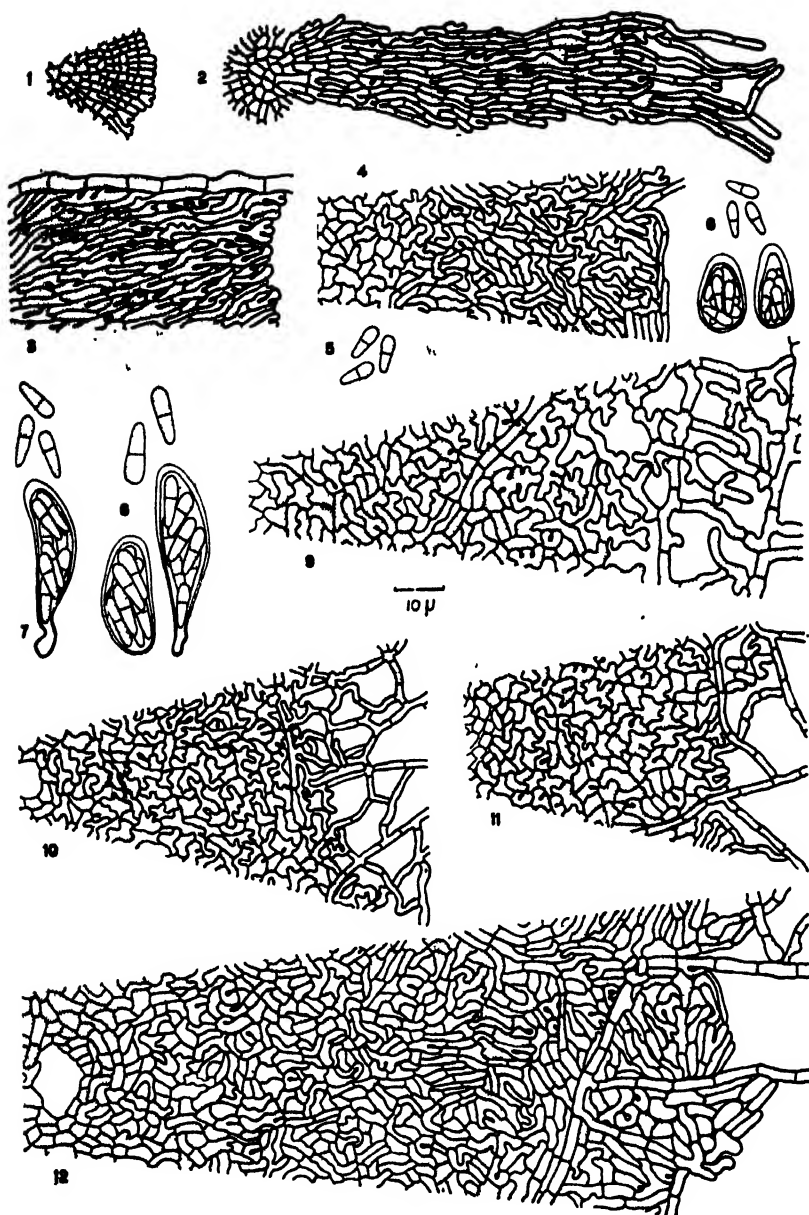
*Microthyrium aspersum* (Berk.) V. Hoehn., Frag. No. 517.

*Calothyrium aspersum* (Berk.) Theiss., Oest. Bot. Zeitschr.  
 1912, p. 219.

Mycelium superficial, composed of brown, irregularly branched, anastomosing hyphae about  $2 \mu$  in diameter, forming irregular, brownish spots on the lower surface of leaves; ascocarps superficial, dimidiate-scutate, orbicular  $137-180 \mu$  in diameter, uniloculate, with a central ostiole; shield (FIG. 4) composed of a pseudoparenchyma of brown, inordinately arranged, sinuous, irregularly lobed cells, becoming plectenchymatous at the margin and merging with the mycelial net; asci pseudoparaphysate, clavate,  $35 \times 9-10 \mu$ , containing eight irregularly arranged ascospores; ascospores (FIG. 5) hyaline, one-septate, non-constricted, oblancoolate, rounded at both ends, anterior cell shorter and broader than the posterior cell,  $8-9 \times 2-2.7 \mu$ .

On leaves of a species of Lauraceae in India.

Only two slides, each bearing a single ascocarp, have been available for study. The first was a mount of an ascocarp from the original collection of *Asterina aspersa* in the herbarium of the Royal Botanic Garden at Kew. No asci were present in this mount; and the ascocarp was  $285 \mu$  in diameter, which is considerably larger than Theissen's description indicates. It was, therefore, uncertain that it was representative of the material upon which Theissen's description of *S. aspersa* was based. The second slide, obtained from the Farlow Herbarium, was prepared by von Hoehnel and was labelled *Microthyrium aspersum*. The dimensions of the ascocarp in this specimen fell within the limits given by Theissen. Examination of this specimen showed that the shield is composed of an irregular pseudoparenchyma (FIG. 4) and established the fact that this is the type of shield structure which characterizes the genus *Stomiopeltis*. Unfortunately, the few ascospores present in the specimen of *S. aspersa* were, as Theissen stated in his original descrip-



FIGS. 1-12. The genus *Stomiopeltis*.

tion, for the most part immature. The specific limits of *S. aspersa* must, therefore, remain in doubt until additional collections are made.

2. *STOMIOPELTIS RUBI* (Fckl.) Petrak, Ann. Myc. 21:15-16. 1923.

*Actinonema rubi* Fckl., Symb., p. 384.

*Asteroma rubi* (Fckl.) Sacc., Syll. Fung. 3: 202.

*Asterella rubi* (Fckl.) v. Hoehn., Ann. Myc. 1905, 326.

*Asterella rubi* var. *rhoina* v. Hoehn., Ann. Myc. 1905, p. 326.

Mycelium superficial, composed of a network of brown, repeatedly branched, anastomosing hyphae  $3-5\ \mu$  in diameter, forming sooty-brown spots on stems; ascocarps superficial, dimidiate-scutate, orbicular,  $64-136\ \mu$  in diameter, uniloculate, centrally ostiolate; shield (FIG. 9) pseudoparenchymatous, composed of brown, inordinately arranged, sinuous, irregularly lobed cells, becoming plectenchymatous at the margin and merging with the mycelial net; asci (FIG. 6) pseudoparaphysate, oblong-ovoid,  $16-28 \times 12\ \mu$ , containing eight irregularly arranged ascospores; ascospores (FIG. 6) hyaline, one-septate, non-constricted, oblanceolate, rounded at both ends, anterior cell shorter and broader than the posterior cell,  $7-12 \times 3-4\ \mu$ .

On living stems of *Rubus idaeus* and *Rhois cotinus* in Austria.

Specimens examined were a fragment of *Actinonema rubi* from Thueman's Myc. Univ. No. 1785 in the herbarium of the Royal Botanic Garden at Kew and von Hoehnel's type specimens of *Asterella rubi* and *A. rubi* var. *rhoina* in the Farlow Herbarium. All three of these specimens apparently represent the same species. The shield is composed of an irregular pseudoparenchyma and is similar in structure to that of *Stomiopeltis aspersa*. Petrak was, therefore, correct in transferring *A. rubi* to *Stomiopeltis*. *A. rubi* var. *rhoina* differs from *A. rubi* only in that it occurs upon a different host (*Rhois cotinus*) and does not form conspicuous spots on the host stems. The latter difference seems to be merely the result of the difference in background furnished by the two hosts. These differences are not considered sufficient to maintain the variety. *A. rubi* var. *rhoina* is, therefore, reduced to synonymy with *Stomiopeltis rubi*.

## 3. STOMIOPELTIS CASSIAE Mendoza, Bot. Gaz. 79: 292. 1925.

Mycelium superficial, composed of a network of branching, anastomosing, brown hyphae  $1-1.3\ \mu$  in diameter, forming faint, olive-colored spots on the upper surface of the host leaves; ascocarps superficial, dimidiate-scutate, orbicular,  $88-134\ \mu$  in diameter, uniloculate, centrally ostiolate; shield (FIG. 10) pseudoparenchymatous, composed of inordinately arranged, sinuous, irregularly lobed, golden-brown cells, becoming plectenchymatous at the margin and merging with the mycelial net; asci (FIG. 7) pseudoparaphysate (?), clavate,  $33-38 \times 9\ \mu$ , eight-spored, prostrate, radially arranged, their apices directed toward the ostiole; ascospores (FIG. 7) hyaline, one-septate, non-constricted, oblanceolate, rounded at both ends, the anterior cell shorter and broader than the posterior cell,  $8-10.5 \times 2.6-3\ \mu$  (about  $13 \times 3\ \mu$  Mendoza) 2-3-seriate.

On leaves of *Cassia* sp. in British Guiana.

The type specimen (No. 115, on *Cassia* sp., British Guiana, 10 July, 1922) from the herbarium of the University of Illinois, the Farlow Herbarium and the New York Botanical Garden has been examined.

Although *Stomiopeltis* is distinguished from *Stomiopeltella* by the presence of paraphyses, Mendoza described *Stomiopeltis cassiae* as being paraphysate. If this were true, the fungus would belong in *Stomiopeltella*. Only a few scattered ascocarps were found in the type material, and it was impossible to determine definitely whether pseudoparaphyses are present. Since, however, this fungus is similar in other respects to species of *Stomiopeltis*, it is retained in this genus until adequate material is available for further study although it must be considered a doubtful species.

Pycnidia were much more abundant on the leaves in the type collection than were ascocarps. These were associated with the ascocarps and superficially were similar to them. The wall of the pycnidium is formed by an irregularly pseudoparenchymatous, ostiolate, dimidiate shield identical in structure with the shield of the ascocarp. Beneath the shield is a hemispherical locule filled with hyaline, cylindrical conidia. These pycnidia are similar to the pycnidia of *S. citri* described by Bitancourt (1934) as *Sirothyrium citri* and possibly represent the pycnidial stage of *S. cassiae*. Since the type material is inadequate, additional collections of *S. cassiae*



will be necessary in order to determine its structure satisfactorily and to demonstrate its connection with the associated pycnidia.

4. *Stomiopeltis suttoniae* (Mendoza) comb. nov.

*Stomiopeltella suttoniae* Mendoza, Bot. Gaz. 79: 292. 1925.

Mycelium superficial, reticulated, composed of brown hyphae 1.5–4  $\mu$  in diameter, forming faint sooty spots on the upper surface of the host leaves; ascocarps superficial, dimidiate-scutate, orbicular, 231–408  $\mu$  in diameter, uniloculate, provided with a central ostiole; shield (FIG. 12) differentiated into a convex central portion, 176–231  $\mu$  in diameter, composed of a pseudoparenchyma of dark-brown, inordinately arranged, sinuous, irregularly lobed cells and a peripheral, flat, lighter-colored plectenchymatous border 27–95  $\mu$  across; asci (FIG. 8) pseudoparaphysate, clavate to ovate-oblong, 30–51  $\times$  12–15  $\mu$ , eight-spored, prostrate, radially disposed, their apices converging toward the ostiole; ascospores (FIG. 8) hyaline, one-septate, non-constricted, oblanceolate, rounded at both ends, anterior cell shorter and broader than the posterior cell, 12–15  $\times$  3.5–5  $\mu$ , 2–3-seriate.

On leaves of *Suttonia lessertiana* in Hawaii.

The type specimen (No. 1032, on *Suttonia lessertiana*, Hawaii, 28 July, 1921) from the herbarium of the University of Illinois, the Farlow Herbarium, and the New York Botanical Garden has been examined.

Although Mendoza described this species as being paraphysate and, therefore, placed it in *Stomiopeltella*, his illustration of the asci (Stevens and Manter, 1925, FIG. 71) shows them to be paraphysate and the legend to this illustration is "*Stomiopeltella suttoniae*. Fig. 71. Ascus with ascospores and paraphysis." Furthermore, sections of ascocarps from the type specimens have demonstrated that pseudoparaphyses are abundantly present between the asci in the locules. Because it is pseudoparaphysate, this species is transferred to *Stomiopeltis*. In the irregularly pseudoparenchymatous structure of the shield it agrees with other species of this genus. It is distinguished from all other species of *Stomiopeltis*, however, by the broad band of plectenchymatous tissue forming the margin of the shield. It should be noted that the ascocarps in specimens which I have examined are much larger than is indicated in Mendoza's original description. These asco-

carps were, however, abundant on the leaves in the type collection, and no other fungus which could possibly fit Mendoza's description was present. This, together with the fact that my measurements of asci and ascospores agree with those given in the original description, inclines me to believe that the specimens from which my description was taken were representative of the material upon which Mendoza based his description of *Stomiopeltella suttoniae*.

5. *STOMIOPELTIS CITRI* Bitancourt, Arq. Inst. Biol. São Paulo 5: 261. 1934.

Mycelium superficial, reticulated, composed of brown hyphae  $0.8-3\ \mu$  in diameter, forming irregular, effused, grayish-sooty spots on the leaves, stems, and fruits of the host; ascocarps superficial, dimidiate-scutate, orbicular,  $140-200\ \mu$  in diameter, uniloculate, centrally ostiolate; shield (FIG. 11) pseudoparenchymatous, composed of inordinately arranged, sinuous, irregularly lobed, brown cells, becoming plectenchymatous at the margin and merging with the mycelial net; asci pseudoparaphysate, clavate to cylindrical,  $22-46 \times 6.5-11\ \mu$ , eight-spored, prostrate, radially arranged, their apices directed toward the ostiole; ascospores hyaline, one-septate, non-constricted, oblancoolate, rounded at both ends, anterior cell broader and shorter than the posterior cell,  $6-11 \times 2-4\ \mu$ , biseriate.

Pycnidia (*Sirothyrium citri* Bitancourt) similar to the ascocarps,  $80-150\ \mu$  in diameter; pycnospores hyaline, cylindrical, rounded at both ends, catenulate,  $2.5-6.5 \times 0.5-1.2\ \mu$ , arising from a hyaline sporogenous layer lining the pycnidium.

On leaves, stems, and fruits of *Citrus* spp. in Brazil.

Specimens (No. 2246, *S. Moreira*, 10 June, 1936 and No. 2669, *E. Ract*, 17 June, 1937) from the Herbario da Secção de Fito-pathologia of the Instituto Biológico de Defesa Agrícola e Animal, São Paulo, Brazil, have been examined and deposited in the Farlow Herbarium.

Although there is a difference in the appearance of the ascocarps, the only quantitative difference between *S. citri* and *S. aspersa* is a slight difference in recorded size of ascospores. This difference is of little value since no adequate measurements have been made of the ascospores of *S. aspersa*. These two species are certainly closely related, and possibly *S. citri* should be considered synonymous with *S. aspersa*.

*S. citri* is the only species of *Stomiopeltis* for which an imperfect stage has been reported. Imperfect stages have, however, been found in a few other species of Hemisphaeriales, and they probably will be found in many others when the species are studied more completely.

6. *Stomiopeltis minor* (Bitancourt) comb. nov.

*Stomiopeltis citri* var. *minor* Bitancourt, Arq. Inst. Biol., São Paulo 5: 261. 1934.

Mycelium superficial, reticulated, composed of brown hyphae, forming grayish-sooty spots on the stems, leaves, and fruits of the host; ascocarps superficial, dimidiate-scutate, orbicular, 50–80  $\mu$  in diameter, uniloculate, centrally ostiolate; shield pseudoparenchymatous, composed of inordinately arranged, sinuous, irregularly lobed, brown cells, becoming plectenchymatous at the margin and merging with the mycelial net; asci pseudoparaphysate, globose to ovate, 17–28  $\times$  7–12  $\mu$ , eight-spored; ascospores hyaline to yellowish, one-septate, non-constricted, oblanceolate, rounded at both ends, anterior cell shorter and broader than the posterior cell, 6–10  $\times$  2–3  $\mu$ .

On leaves, stems, and fruits of *Citrus* spp. in Brazil.

This species occurs in association with *S. citri* on the same hosts. Bitancourt appears to have been extremely conservative in considering it merely a variety of *S. citri*. It is more distinct from *S. citri* than are some other species, such as *S. aspersa*. In fact, it seems most closely related to *S. rubi* in its morphology, and perhaps it should be reduced to synonymy with the latter species. For the present, however, it is considered distinct.

7. *Stomiopeltis polyloculatis* sp. nov.

Mycelio superficiali, maculas olivaceas, orbiculares 5–10 mm. diam. vel irregulares et confluentes, tenues efformante, ex hyphis 2–3  $\mu$  diam., brunneis, ramoso-reticulatis constituto; ascomate libero, orbiculari, 286–680  $\mu$  diam. (medio 446  $\mu$ ), glabro, dimidiato-scutato, in mycelium reticulatum sensim abuente; contextu scuti brunneo, pseudoparenchymatico, ex cellulis inordinate dispositis, 6–13.5  $\times$  1.5–3.0  $\mu$ , irregulariter sinuosis composito, periph-erice plectenchymatico; loculis ascigeris numerosis, 2–16 (plerumque 6), poro centrali praeditis; ascis oblongis vel cylindraceutis, sessilibus vel breviter stipitatis, 35.0–53.2  $\times$  8.4–13.5  $\mu$  (medio 43.96  $\times$  10–22  $\mu$ ), octosporis, bitunicatis, pseudoparaphysatis, prostratis, radialiter dispositis, apicibus centrum

versus convergentibus; ascosporis 2-3 seriatis, hyalinis, rectis, oblanceolatis, utrimque obtusiusculis, uni-septatis, non-constrictis, superiore loculo brevioribus ac crassioribus,  $13.5-21.0 \times 4.1-4.8 \mu$  (medio  $17.1 \times 4.4 \mu$ ).

Hab. in culmis vivis *Arundinariae tectae* (Walt.) Muhl. Experiment, Georgia, U. S. A.

The type specimen has been deposited in the Farlow Herbarium, Harvard University, and co-type specimens have been placed in the Mycological Collections of the Bureau of Plant Industry, the herbarium of the New York Botanical Garden, the herbarium of the University of Illinois, and the herbarium of the Royal Botanic Garden at Kew, Surrey, England.

The superficial mycelium and the superficial, dimidiate-scutate ascocarps of this fungus place it at once in the order Hemisphaeriales. Because its shield is non-radiate in structure, it belongs in the family Hemisphaeriaceae. The structure of the shield, a pseudoparenchymatous tissue composed of irregularly lobed, sinuous cells, and the presence of a dark-colored mycelium are characteristic of the subfamily Plochmopeltineae. The characters which show its affinities with the genus *Stomiopeltis* and which separate it from other genera in the Plochmopeltineae are the hyalodidymous ascospores, the presence of pseudoparaphyses and ostioles, and the lack of setae and hyphopodia on the ascocarps and mycelium. Within the genus *Stomiopeltis* it differs from all previously described species in the larger size of the ascocarps and ascospores and in that the ascocarps always contain more than one ascigerous locule.

Inclusion of *S. polyloculatis*, a species with polyloculate ascocarps, in a genus whose species generally possess uniloculate ascocarps might be questioned, especially since variation in number of locules has been employed to some extent in the separation of genera in the Hemisphaeriales (Theissen and Sydow 1917). In some species of *Stomiopeltis* which are usually uniloculate, however, polyloculate ascocarps containing two to five locules may occasionally be found. Since such variation may occur in a single species of the genus, the inclusion of this polyloculate species in *Stomiopeltis* seems justified. Further, it seems doubtful in any case that variation in number of locules in the ascocarp should be considered a suitable criterion for the separation of genera.

## EXCLUDED SPECIES

1. STOMIOPELTIS HETEROMERIS Syd., Ann. Myc. 25: 84-85. 1927.  
= *Calothyrium* sp. (Microthyriaceae)

A part of the original collection of this species (Sydow, No. 169 d, on living leaves of *Phoebe neurophylla*, Costa Rica, 9 February, 1925) in the Mycological Collections of the Bureau of Plant Industry has been examined. The young ascocarps are regularly radiate, resembling those of *Microthyrium* (FIG. 1). In mature ascocarps the cells of the radiating hyphae become irregularly lobed, and the hyphae become curved and somewhat interwoven (FIG. 2). The radiate structure of the shield is still evident, however, as Sydow recognized in his description of this species ("thyriothechia . . . ex hyphis radiantibus sed fortiter undulatis vel fere maeandrice curvatis . . . contexto"). The irregular, undulating appearance of the hyphae does not alter the fact that the shield is fundamentally radiate. *S. heteromeris* is, therefore, transferred to the Microthyriaceae. Because the ascospores are hyalobidymous, it is considered to be a species of *Calothyrium*.

2. STOMIOPELTIS CHILENSIS Syd., Ann. Myc. 30: 87-88. 1932.  
= *Asterinella puiggarii* (Speg.) Theiss. (Microthyriaceae)

A part of Sydow's type specimens (*E. Werdermann*, No. 1768, on living leaves of *Myrtis luma*, Chile, February 1924) from the Farlow Herbarium has been examined. As in *S. heteromeris* the shield is fundamentally radiate in structure (FIG. 3). Sydow, himself, described the ascocarp of *S. chilensis* as being indistinctly radiate ("Strato tegente . . . maeandrice plectenchymatico, ex hyphis . . . indistincte radiantibus maeandrice curvatis constante"). Petrak (1940) has previously recognized the fact that *S. chilensis* belongs in the Microthyriaceae rather than in the Hemisphaeriaceae. He considered it a poorly developed form of *Asterinella puiggarii* and reduced it to synonymy with this species.

3. STOMIOPELTIS PHILIPPINENSIS Syd., Ann. Myc. 29: 248-249. 1931. = species of Microthyriaceae

No specimens of this species have been examined. Sydow, however, described the ascocarp as being in part indistinctly radiate

("strato tegente . . . maeandrice et minute plectenchymatico-cellulosis vel parum elongatis . . . metientibus, partim ex hyphis plus minus fortiter undulato vel maeandrice curvatis saepe etiam indistincte radiantibus . . . constante"). For this reason *S. philippinensis* is tentatively excluded from the Hemisphaericeae. It is referred to the Microthyriaceae although its position cannot be definitely determined until the type specimen is available for study.

#### MORPHOLOGY OF STOMIOPELTIS POLYLOCULATIS

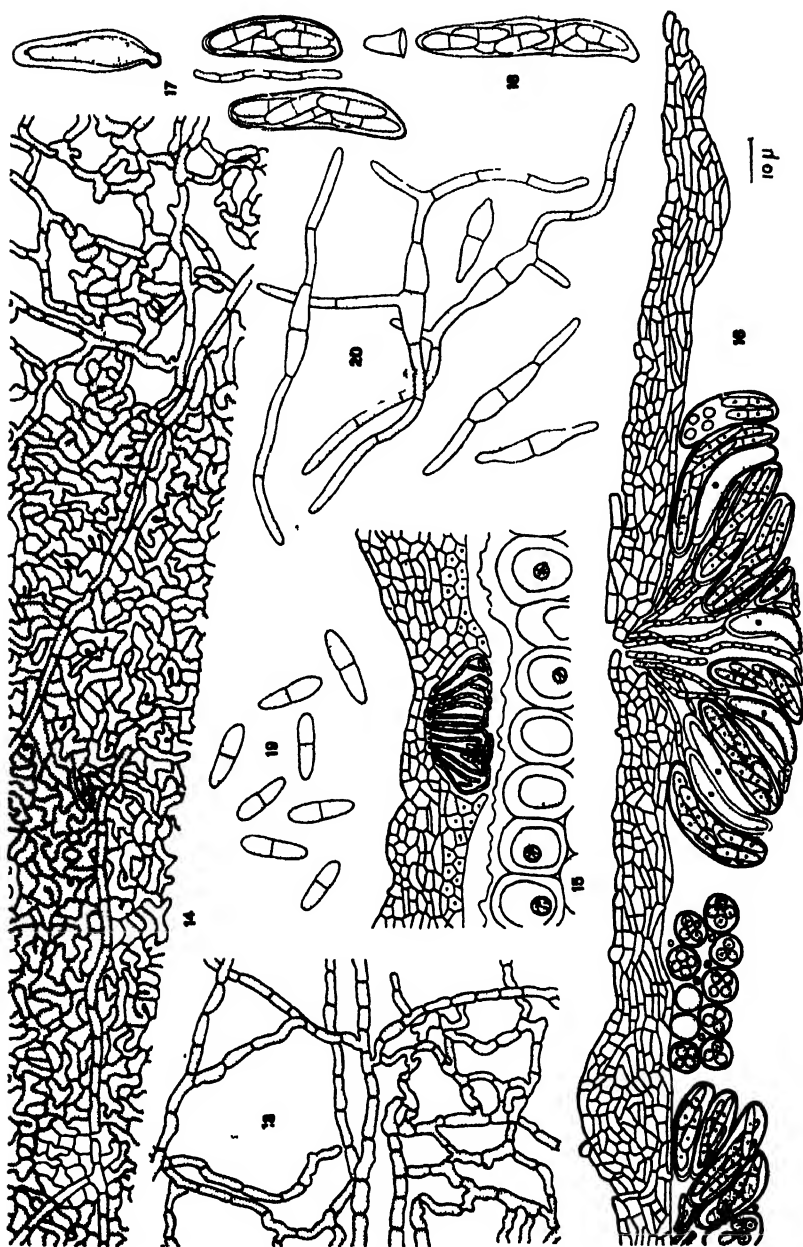
Infection of the current season's canes of *Arundinaria tecta* is accomplished by ascospores during late spring. The resulting mycelium forms a network over the surface of the cane, producing an olive-green blotch. The blotches (FIG. 21) may be circular and five to ten mm. in diameter; or they may spread irregularly, become confluent, and cover considerable portions of the cane. No conidial or spermogonial stage has been observed. During July, however, the young ascocarps appear as black discs, ultimately about 0.5 mm. in diameter, scattered in the mycelium (FIG. 21). Asci are formed within locules in the ascocarps during October and remain in the uninucleate stage during the winter. Ascospores develop during March and April of the following year, and mature ascospores are present from late April through June. These infect the new canes of the host, completing the life cycle of the fungus.

Other undetermined species of *Stomiopeltis* and species of *Microthyriella* frequently are found associated with *S. polyloculatis*. These may be easily distinguished, however, by their macroscopic appearance. The ascocarps of the other species of *Stomiopeltis* are much smaller, being one-fifth or less the diameter of those of *S. polyloculatis*; and, although the ascocarps of the *Microthyriella* species rival those of *S. polyloculatis* in size, they do not appear in blotches such as are characteristic of *Stomiopeltis* species.

The mycelium (FIG. 13) of *S. polyloculatis* is entirely superficial. It rests upon the unaltered cuticle of the canes and does not produce haustoria. The fact that the fungus occurs only upon living canes and that there is no evidence of any external source of food, such as sucking insects or their excretions indicates that it is parasitic. Nevertheless, it is difficult to understand how nutrients can be absorbed directly through the thick epidermal walls and heavy

cuticle in the absence of any penetration of the host. The mycelium is composed of brown hyphae  $2-3\mu$  in diameter which branch repeatedly and anastomose freely to form a close reticulum. The cells are short to long cylindrical and may be regular or irregularly lobed and twisted. Hyphopodia are lacking. Ascocarps appear as local thickenings in the mycelium. In the formation of an ascocarp hyphae of the superficial mycelium produce branches which by twisting and branching and by irregular extensions and fusions of their cells fill the interstices of the mycelial net to form a continuous, compact tissue. This is the outer layer of the shield of the ascocarp. At the margin of this flat, orbicular shield (FIG. 14) the hyphal branches are more loosely interwoven to form a plectenchymatous tissue which merges with the surrounding mycelial net. Toward the center of the shield the hyphae, except for the principal hyphae of the mycelium which remain distinct as a network over the surface of the shield, lose their identity; and the tissue formed may best be described as a pseudoparenchyma composed of tortuous, irregularly lobed cells. Seen in surface view, the tissue of Spermatophytes which it approaches most closely is the epidermis, although these fungous cells are often elongated and are even more irregular in outline than are the usual epidermal cells.

Additional layers of cells are added beneath the first formed layer until the shield becomes two to eight cells thick. These cells are thick-walled and brown. Local more opaque spots which appear in the shield in surface view are seen in sections to be produced by small hemispherical thickenings (FIG. 16) which are formed at intervals in the shield. The function of these thickenings is not apparent. A layer of hyaline cells two or three cells in thickness is formed over the lower surface of the shield. These cells are thin-walled and uninucleate. For the most part they become enlarged, and their protoplasm becomes thin; but at intervals groups of cells remain small and retain a denser protoplasm. These cells produce branches composed of small, cylindrical, uninucleate cells which grow downward, their tips directed against the host cuticle (FIG. 15). These hyphae are pseudoparaphyses. By continued growth they raise the portion of the shield immediately above them from the cuticle and create a locule within the stroma.



FIGS. 13-20. The genus *Stomiopeltis*.



Toward the base of the locule the pseudoparaphyses bend outward, expanding the locule centrifugally at the expense of the large, thin-walled cells of the surrounding stroma which are crushed and disintegrated. The tips of the pseudoparaphyses turn inward at the cuticle and intertwine to form a floor to the locule. The asci arise in the base of the locule and grow upward among the pseudoparaphyses. In September, prior to the formation of the young asci, larger, binucleate cells, which probably are ascogenous elements, have been observed among the pseudoparaphyses in the base of the locule. Only a few stages in the development of the ascocarp have been seen, however, and the origin of ascogenous hyphae and asci has not been observed.

From two to sixteen locules are thus formed within the stroma of each ascocarp. The cells in the shield above the center of each locule remain thin-walled and hyaline at the point where each ostiole will form, appearing as translucent areas in the shield. The number of locules may thus be determined in surface view at early stages in the development of the ascocarp.

At maturity the ascocarp consists of a flattened, inverted saucer-shaped shield 286 to 680  $\mu$  in diameter covering a number of broadly flask-shaped clusters of pseudoparaphyses and asci (FIG. 16). The asci are more or less prostrate and are arranged radially, their bases lying at the periphery of the locule, their apices converging toward the center. Above the center of the locule the thin-walled cells of the shield disintegrate to form the ostiole. The locules spread out so that they occupy almost the entire space beneath the shield. Often they are in contact with one another. Sometimes a few crushed stromal cells separate them slightly. The asci (FIG. 17) are oblong to cylindrical, 35.0–53.2  $\times$  8.4–13.5  $\mu$ , sessile or short-stipitate, and thick-walled. Each contains eight hyaline, oblongate, 2–3-seriate ascospores measuring 13.5–21.0  $\times$  4.05–4.8  $\mu$ . The ascospores (FIG. 19) are one-septate and scarcely if at all constricted at the septum. Both ends are rounded. The posterior cell is, however, slightly longer and narrower than the anterior cell.

At maturity the ascus swells when moistened and it is then apparent that the thick ascus wall is composed of two layers. The thin outer layer splits circumscissily near the apex of the ascus,



FIG. 21. *Stomiopeltis polyloculatis*, habit photograph showing ascocarps scattered in olive-colored patches on canes of *Arundinaria tecta*  $\times 1\frac{1}{2}$ .

and the tip is forced off in the form of a small cap (FIG. 18). The thick, gelatinous inner layer then expands to form an elongated sac which protrudes through the ostiole. The ascospores move up into this sac and are forcibly discharged one after another through an elastic pore in the apex.

On germination (FIG. 20) each ascospore produces one or two germ tubes from the sides or, usually, from the end of each cell. The germ tubes elongate and become septate to form a mycelium. On agar media the mycelium forms small, hemispherical, grayish-brown colonies not more than a centimeter in diameter. Further growth in culture has not been obtained.

#### DISCUSSION

In *Stomiopeltis polyloculatis* the locule in the dimidiate ascostroma is formed by the growth of pseudoparaphyses. These are simple vertical hyphae composed of uninucleate cells and attached at both the top and bottom of the locule. The asci originate in the base of the locule thus formed and grow upward among the pseudoparaphyses. In locule structure *S. polyloculatis* therefore agrees with *Myiocopron smilacis* (De Not.) Sacc. and may be placed in the developmental group previously designated Type 1 (Luttrell 1944). Study of other genera of the Hemisphaeriaceae has shown that species of *Microthyriella* and of *Schisothyrium* belong in the group included under Type 2 (Luttrell 1944). These two fundamentally different developmental types occur, therefore, in the nonradiate Hemisphaeriaceae as well as in the radiate Microthyriaceae. If shield structure and insertion of the ascocarp, characters now employed in the separation of families in the Hemisphaeriales, were considered of minor importance, the order might be divided into two families upon the basis of developmental type. The pseudoparaphysate forms belonging to Type 1 might then constitute a single family; whereas the forms lacking pseudoparaphyses, which are included under Type 2, might be segregated in a second family. If, however, such importance were attached to the internal structure of the locule, the pseudoparaphysate Hemisphaeriales would perhaps be considered more closely related to the Pseudosphaeriales (sensu Miller 1938) than to the non-pseudoparaphysate members of the same order. For example, if the differences in stromal develop-

ment are disregarded, the structure of the locule in *Myiocopron smilacis* (Hemisphaeriales) is essentially the same as in *Diobotryon morbosum* (S.) Theiss. and Syd. (Pseudosphaeriales) but is quite different from that in *Morenoella quercina* (Ellis and Martin) Theiss. (Hemisphaeriales). It is evident that use of this character as a taxonomic criterion of primary importance would necessitate extensive revision of the Pyrenomycetes. Such changes in the present classification should, however, await more thorough study of development in other orders of the Pyrenomycetes as well as in the Hemisphaeriales.

Since the order Hemisphaeriales itself is founded upon gross morphological characteristics of the ascocarp, the separation of families within the order may well be based upon similar characters. The primary subdivision of the Hemisphaeriales into radiate and non-radiate forms is, for the present at least, a reasonable and practical means of classification although the advisability of further division of the radiate forms upon the basis of insertion of the ascocarp (as in the separation of the Polystomellaceae, and possibly the Stigmatiaceae, from the Microthyriaceae) may be questioned. Nevertheless, Petrak (1929) criticized the separation of the Microthyriaceae and the Hemisphaeriaceae upon this basis. His objection was that there are many transitional forms which must be described as "undeutlich radiar" and that these forms have been placed in the Hemisphaeriaceae as well as in the Microthyriaceae. *Stomiopeltis heteromeris* and *S. chilensis* are examples of these indistinctly radiate forms. Sydow placed these two species in the Hemisphaeriaceae; but in my opinion, they belong in the Microthyriaceae. The ascocarps of these species are radiate in origin; and their fundamentally radiate structure, although somewhat obscured, is still evident at maturity. If care is exercised in separating such indistinctly radiate forms from the non-radiate forms, it seems that the present division between the Hemisphaeriaceae and the Microthyriaceae may be satisfactorily maintained.

On the other hand, the separation of two of the subfamilies of the Hemisphaeriaceae, the Thrausmopeltineae and the Plochmopeltineae, is uncertain. Theissen and Sydow (1917) delimited them as follows: Thrausmopeltineae—no free mycelium, shield pseudo-parenchymatous; Plochmopeltineae—free mycelium present, shield

wavy plectenchymatic. Petrak (1929) later reduced the type genus of the Plochrompeltineae, *Plochrompeltis*, to synonymy with *Microthyriella* (Thrausmopeltineae); and the type and only species of *Plochrompeltis*, *P. intricata* (E. & M.) Theiss., became *M. intricata* (E. & M.) Petr. He pointed out that, while the mycelium is better developed in *Plochrompeltis*, a hyaline mycelial net is present in species of *Microthyriella*. He stated further that in shield structure also the two genera intergrade. Examination of the genus *Stomiopeltis* has produced support for Petrak's criticism of the separation of the Plochrompeltineae from the Thrausmopeltineae. A superficial mycelium is present in genera of the Thrausmopeltineae such as *Microthyriella* and *Schizothyrium* as well as in *Stomiopeltis*. The only difference is that in the former it is hyaline and inconspicuous, whereas in the latter it is dark-colored and usually produces spots on the surface of the host. Furthermore, the shield in *Stomiopeltis* is pseudoparenchymatous as it is in genera of the Thrausmopeltineae. *Stomiopeltis* differs only in that the cells composing the pseudoparenchyma are irregularly lobed and sinuous. It appears to be closely related to the genus *Clypeolum* in the Thrausmopeltineae. Further study of the limits of variation in the Thrausmopeltineae will be necessary to determine whether these differences in color of mycelium and in shape of shield cells should be considered sufficient basis for the maintenance of the Plochrompeltineae as a distinct subfamily of the Hemisphaeriaceae.

#### SUMMARY

Of the seven described species of *Stomiopeltis* (Hemisphaeriaceae) *S. heteromeris* Syd., *S. chilensis* Syd., and *S. philippinensis* Syd., because of their radiate structure, are transferred to the Microthyriaceae.

The four remaining species, *S. rubi* (Fckl.) Petr., *S. cassiae* Mendoza, *S. citri* Bitancourt, and the type of the genus, *S. aspersa* (Berk.) Theiss., form a distinct group in the Hemisphaeriaceae characterized by the non-radiate, irregularly pseudoparenchymic structure of the shield of the superficial, dimidiate-scutate ascomycarp, the hyalodidymous ascospores, the presence of pseudoparaphyses and ostioles, and the dark-colored superficial mycelium.

*S. citri* var. *minor* Bitancourt is elevated to the rank of species, and becomes *S. minor* (Bitan.) Luttrell.

*Stomiopeltella suttoniae* Mendoza, because it is pseudoparaphysate, is transferred to *Stomiopeltis* and becomes *Stomiopeltis suttoniae* (Mendoza) Luttrell.

A fungus found on *Arundinaria tecta* (Walt.) Muhl. in Georgia which differs from all previously described species of *Stomiopeltis* in that its ascocarps are polyloculate is added to the genus as a new species, *S. polyloculatis* Luttrell. The presence of more than one locule in the ascocarp is not considered sufficient basis for the formation of a separate genus.

In *S. polyloculatis* the thick-walled, bitunicate asci develop within locules created in the dimidiate-scutate ascocarps by the growth of pseudoparaphyses.

Presence or absence of pseudoparaphyses might be employed as the primary criterion in the separation of families in the Hemisphaeriales; but in the absence of sufficient data on development of the ascocarps in the Pyrenomycetes, the present classification of the order upon the basis of shield structure should be maintained.

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### EXPLANATION OF FIGURES

FIGS. 1-12. Drawings made with the aid of an Abbé camera lucida using a 10X ocular and a 2 mm. objective; all to scale shown in figure 9. 1, *Stomiopeltis heteromeris*, portion of shield of young ascocarp; 2, *S. heteromeris*, portion of shield of mature ascocarp; 3, *S. chilensis*, portion of shield of mature ascocarp; 4, *S. aspersa*, portion of shield of mature ascocarp; 5, *S. aspersa*, ascospores; 6, *S. rubi*, asci and ascospores; 7, *S. cassiae*, ascus and ascospores; 8, *S. suttoniae*, asci and ascospores; 9, *S. rubi*, portion of shield of mature ascocarp; 10, *S. cassiae*, portion of shield of mature ascocarp; 11, *S. citri*, portion of shield of mature ascocarp; 12, *S. suttoniae*, portion of shield of mature ascocarp.

FIGS. 13-20. *Stomiopeltis polyloculatis*; drawings made with the aid of an Abbé camera lucida using a 10X ocular and 2 mm. objective; all to scale shown in figure 16. 13, portion of the superficial mycelium; 14, portion of shield of mature ascocarp; 15, section of locule in young ascocarp showing pseudoparaphyses; 16, section through a mature ascocarp showing several locules beneath the shield; 17, young and mature asci and a pseudoparaphysis; 18, dehiscence of the two-walled ascus; 19, mature ascospores after discharge from the ascus; 20, germinating ascospores.

# STUDIES ON THE STRUCTURE OF STREPTOMYCES GRISEUS \*

FERNANDO CARVAJAL

Studies on the structure of *Streptomyces griseus* have been carried on with the aid of an RCA electron microscope, type "EMB-4," and with a light microscope. Fixed preparations, stained or unstained, were used. Living as well as fixed material was also studied with the aid of a light microscope at magnifications from 100 to 1500 times.

Several strains of *S. griseus* were used including active streptomycin producers and inactive strains. All these strains were isolated by the writer with the exception of three from Dr. S. A. Waksman and one from the American Type Culture Collection.

The following procedure for preparation of aerial mycelium and spore chains for electron microscope studies gave satisfactory results. Material from cultures varying in age from one to seven days old was obtained by lightly touching a platinum loop containing a film of distilled, sterile water to the aerial growth of the organism. The contents on the loop (film of water) are placed on the collodion membrane of the screen and left for a few minutes to dry. The screen is then put in the electron microscope to be observed.

## THE MYCELIUM

The active vegetative portion of *S. griseus* is differentiated as a definite mycelium. It is usually less conspicuous than are the fruiting structures. The mycelium is well developed, coenocytic (when young) and well branched usually in a typical monopodial form, straight or wavy. Rarely two or more branches are seen growing from the same place on the main hypha. The basal portion of a new branch is usually constricted and perpendicular to the main hypha (FIG. 2: B and C). No true septa have been observed in the vegetative young mycelium, but they are sometimes

\* Contribution from Schenley Laboratories, Inc., Lawrenceburg, Indiana.



seen in older mycelium. Septa are formed in practically all cases in the delimitations of the reproductive cells. There is more variation in the diameter of the mycelium than in the diameter of the spores. The diameter of the mycelium ranged commonly from 0.3 to 2 microns, rarely more; but usually varied from 0.5 to 1.3 microns. Variations in the diameter of the mycelium were observed even in the same filament, such as thinning or thickening, constrictions, etc. (FIG. 2: *B* and *C*). The hyphal walls are smooth. The young, growing portions of the mycelium are usually dense in protoplasmic contents. Vacuoles were often observed in the cytoplasm of older mycelium.

#### SPORE FORMATION

*S. griseus* has a definite aerial sporogenous apparatus. Reproduction is by means of unicellular, asexual spores (conidia) which are produced exogenously in chains on the aerial mycelium and are typically wind borne. Such reproductive cells correspond morphologically to the conidia of the higher fungi (Moniliales).

The spores as formed in the aerial mycelium on solid and liquid media were found to be of various shapes: barrel, oval, bean, spherical, and cylindrical (FIG. 1: *B*, *C*, *D*, *E*; FIG. 2: *A*; and FIG. 3: *D*). The spore dimensions usually fall within the ranges of  $0.7\text{--}0.9 \times 0.7\text{--}1.9$  microns. In the same spore chain, differences in size and shape were often noted (FIG. 1: *C* and *E*). The behavior of the spore formation was very similar to that reported by early workers in the Actinomycetes (1, 2). The aerial sporogenous hyphae which were often clavate were, at first, continuous and rich in protoplasmic contents. Transverse septa were then laid down simultaneously dividing the structure into uninucleate or multinucleate segments (FIG. 1: *A*). Each cell between two septa increased in size, and constrictions appeared at the septa (FIG. 1: *B*) so that the spores were held in chains and connected to each other by very narrow and fragile isthmuses (FIG. 1: *C* and *E*). In some instances these connecting bridges appeared colorless and appeared to be small, empty tubes (FIG. 1: *E*). The spores increased considerably in size and their cell walls thickened. Sometimes apparently empty spores (which do not stain) were seen in the spore chains.

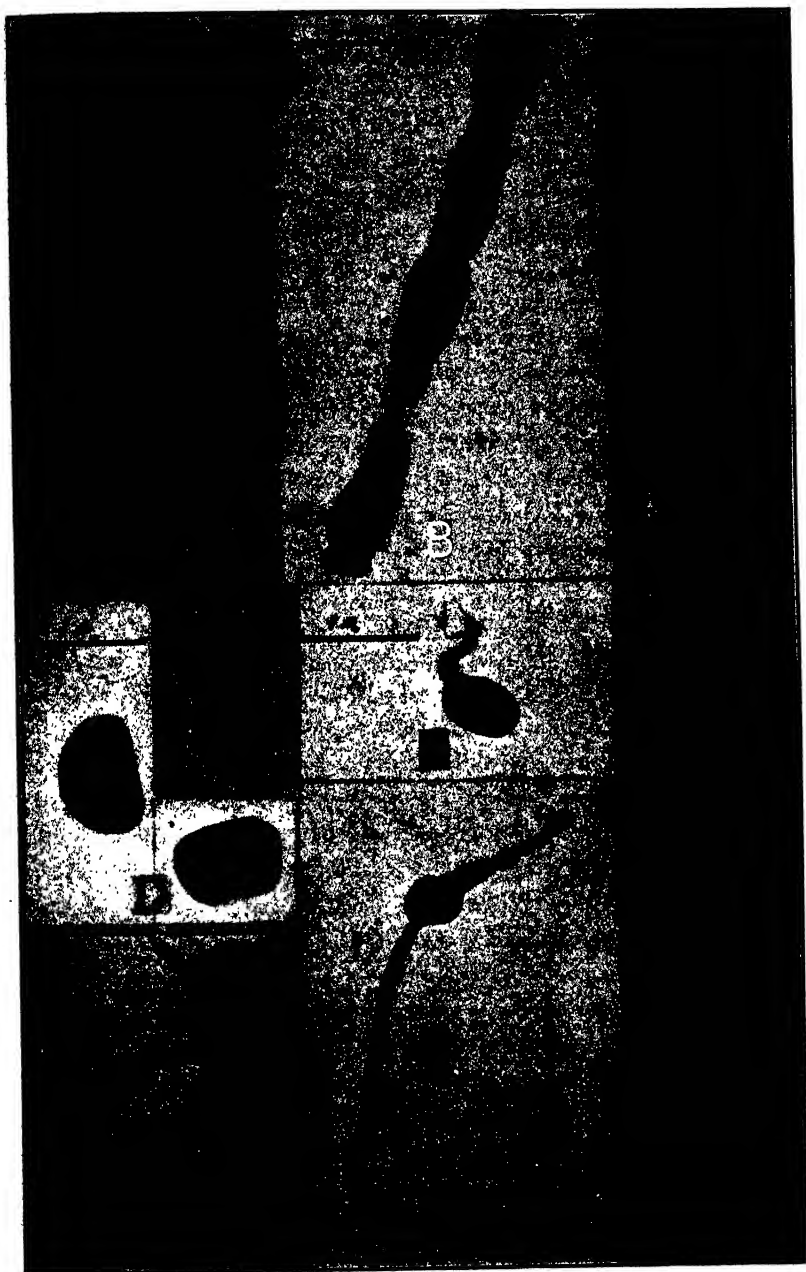


FIG. 1. *Streptomyces griseus*.

Septation sometimes occurred in several branches from an axial filament at the same time whereas, on other occasions with mature spore chains, septate sporogenous hyphae and non-septate filaments were seen in branches from an axial hypha.

In the early stages of spore formation, the aerial mycelium first appears to be whitish to the naked eye; but soon, with the maturation and increase in number of spores, the surface of the culture becomes buff in color, with different tones of green, rose, yellow, orange, gray, cream, and brownish colors according to the nutrient medium used and the strain of the organism. The progressive stages in the development of sporogenous hyphae occurring in *S. griseus* can be easily observed on cultures one to three days old produced on a good sporulation medium (surface seeding).

The aerial, spore-bearing hyphae showed some differences in morphology among *S. griseus* strains growing on the same medium. Differences were found among active strains as well as among inactive ones. The main axial filament was usually branched monopodially. The fertile branches were straight or only slightly wavy. In some strains which sporulate poorly, it was found that comparatively few and scattered sporogenous filaments occurred, especially at the margin of colonies or in concentric rings. These conidiophores or sporogenous hyphae appeared small and often unbranched and were borne directly on the vegetative mycelium, or they were poorly branched with a few short secondary spore chains. On the contrary, strains which sporulate well were seen to have well branched sporogenous hyphae; and the individual spore chain often reached great length. Over 200 spores have been counted on a single spore chain from a culture three days old. The vegetative mycelium gives rise to the aerial mycelium in a monopodial fashion. An aerial filament usually arises at right angles from the horizontal vegetative hypha. Several aerial filaments may arise from the same hypha. Sporogenesis may start at the point of origin of the aerial filament or there may be a short space of sterile hypha.

Mature aerial spores of *S. griseus* often show small fragments of transparent film adhering to the outside of the spores. Figure 3: *D* shows these film particles attached to the exterior of the spores. Figure 1: *D* shows four spores after the film fragments have been

removed by washing and centrifuging several times with distilled water.

#### SPORE GERMINATION

The spores of *S. griseus* in nutrient broth or solid media usually germinate in a short time at one or both ends. The germ tubes sometimes appear simultaneously, but often one is delayed. The points at which the germ tubes appear are usually the previous points of attachment to other spores or to the hypha. Sometimes the germ tubes arise at various points other than at the ends of the spores. Rarely do the spores germinate by more than two germ tubes. In germination, small protuberances arise at the end or ends of the spores. These elongate to form the germ tube. As the tube elongates by apical growth, the contents of the spore pass into it and the nuclei actively divide; growth and branching of the resulting mycelium follow and finally reproduction starts again. In some instances the original shape of the spore is somewhat modified. Some spores may swell considerably before putting out the germ tubes. Figure 1: *F*, *G*, and *H* (electron microscope pictures) show three germinated spores of *S. griseus*.

Under favorable temperature and moisture conditions, spores may germinate in a growing culture while still in the aerial chain. Figure 1, *E* shows two germ tubes which originated from the constriction or isthmus which connects the two spores. The germ tubes are emerging at right angles to the main axis of the spore chain. Hyphal fusions were often observed. Germ tubes may fuse with each other.

#### THE NUCLEUS OF *S. GRISEUS*

The conspicuous spheroidal and homogenous bodies which are embedded in the cytoplasm are assumed to be the nuclei of *S. griseus*. The fact that they are consistently regular in size, position, and distribution throughout the thallus of this organism, as studied with the light and electron microscopes in many preparations, is taken as basis to support this statement.

The nucleus of *S. griseus* is especially conspicuous and may be demonstrated in the germ tubes, young mycelium, and in the developing spores (FIG. 1: *B*, *F*, *E*, *G*, *H* and FIG. 2: *A*). The

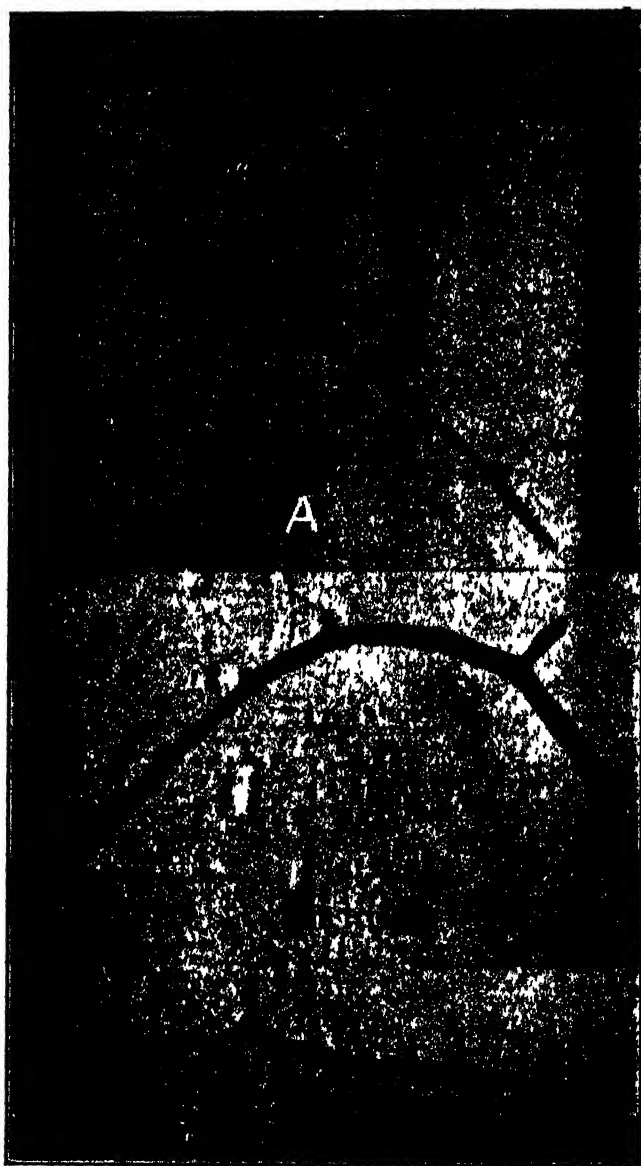


FIG. 2. *Streptomyces griseus*.

nuclei in the mycelium are well distributed throughout the cytoplasm (FIG. 2: *A*) and they move with the cytoplasm. The spores may be uninucleate or multinucleate. The nucleus usually occupies the center of the spore, but may also be found in any other position in the spore.

The number of nuclei is by no means always proportional to the size of the cell; for instance the axial cell at the tip sometimes contains a single nucleus which is slightly larger than the regular sized nuclei in the other cells.

The nuclei are not to be confused here with the metachromatic granules of Neukirch (3) and Schütze (4).

#### OTHER ACTINOMYCETES

Other members of the Actinomycetes were also studied. For instance figure 3: *A*, *B*, and *C* represent spores and spore formation of a chromogenous species of *Streptomyces* which forms spiral spore chains on the aerial mycelium. This *Streptomyces* sp. produces an antibiotic material which is active against gram negative



FIG. 3. *Streptomyces griseus*.

and gram positive bacteria. Figure 3: *A* shows an axial aerial hypha with two young spores forming on the side branch; *B* shows a young spore chain, and *C* represents several spores showing differences in shape and size. The spore formation of this organism and others studied was very similar to that of *S. griseus*. The reproductive processes of most *Streptomyces* are far more highly developed than those of any of the bacteria.

#### SUMMARY

1. Structural studies of active and inactive strains of *S. griseus* were made with light and electron microscopes.

2. The vegetative mycelium when young is coenocytic and well branched typically in a monopodial form. Transverse septa are formed in practically all cases in the delimitation of the reproductive cells. Also septa occasionally were observed in the older mycelium.

3. The basal portions of new mycelial branches were often seen to be constricted.

4. The reproduction of *S. griseus* occurs by means of unicellular, asexual spores (conidia) which are exogenously borne in chains on the aerial mycelium.

5. The spores of *S. griseus* were found to be of various shapes: barrel, oval, bean, spherical, and cylindrical. Differences in shape and size were found often, even among the spores of the same chain.

6. The progressive stages in the development of sporogenous hyphae can be observed easily in a one to three day old culture on a good sporulation media.

7. The aerial sporogenous hyphae showed some differences in morphology among strains growing upon the same medium. Differences were found among active strains, as well as among inactive strains.

8. Mature aerial spores often show small fragments of transparent film adhering to the outside wall.

9. The spores of *S. griseus* usually germinate at one or both ends, usually from the points at which they were attached to the adjacent spores or to the hypha. Rarely do they germinate by more than two germ tubes.

10. Hyphal fusions and germ tube fusions were observed.

11. The nucleus of *S. griseus* may readily be demonstrated in the germ tubes, young mycelium, and in the developing spores. The nuclei are well distributed throughout the cytoplasm of the mycelium. The spores may be uninucleate or multinucleate.

12. Spore formation of other species of *Streptomyces* was very similar to that of *S. griseus*.

13. The reproductive processes of most species of *Streptomyces* are far more highly developed than those of any of the bacteria.

The writer gratefully acknowledges the assistance of Dr. Seth Pope for helpful criticism of the manuscript and of Mr. G. B. Levy and Mr. Denman Shaw for the technical photographic help and the operation of the electron microscope.

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#### EXPLANATION OF FIGURES

FIG. 1. Electron microscope photographs of *Streptomyces griseus* SL-842 (streptomycin producer). *A*, an aerial sporogenous hypha showing septation prior to spore formation. *B*, a more advanced stage in spore formation. *C*, a well matured, four-spored chain showing the isthmuses and differences in spore sizes. *D*, four washed spores. *E*, mature spore chain, germinated spores, and isthmuses, showing also an empty isthmus in the lower portion of the chain. *F*, a spore germinated by a single germ tube. *G* and *H*, two spores germinated by two germ tubes.

FIG. 2. Electron microscope photographs of *Streptomyces griseus* SL-842. *A*, shows young branched mycelium with well distributed nuclei; also several spores showing relationship of sizes. *B* and *C*, mycelium from a submerged culture showing branching and irregularities in diameter. Some of the new branches constricted at their bases.

FIG. 3. *A*, *B*, and *C* are electron microscope photographs of a species of *Streptomyces*. *A*, shows a sporogenous hypha bearing two young spores at the side branch. *B*, a young spore chain. *C*, typical mature spores of various sizes and shapes. *D*, two electron microscope photographs of spores of *Streptomyces griseus* SL-842 showing film fragments adhering to their exterior.



## BIOLOGIC STRAINS OF STREPTOMYCES GRISEUS \*

FERNANDO CARVAJAL

*S. griseus* was first described by Krainsky in 1914 (3) as *Actinomyces griseus*, but according to Drechsler (2) this organism is the same species described by Rossi-Doria in 1892 (4) as *Streptothrix alba*. Krainsky's original description was amended by Waksman and Curtis (7, 8). Following the recent classification of the Actinomycetes (9) this organism is now identified as *Streptomyces griseus* (Krainsky) Waksman and Henrici.

*S. griseus* has been isolated many times from soil samples, river mud, insects, plant roots, air, foodstuff, animal excreta, water, decomposing plant material, and dust.

The procedure for isolation from soil samples and the testing of *S. griseus* was also used with other microorganisms in the search for antibiotic substances. Soil dilutions employed in isolation work ranged from 1:1000 up to 1:20,000,000. For material such as fresh river mud, dilutions of 1:100,000 up to 1:20,000,000 have given good results. The two media most used were of the following composition. 1. Czapek's modified medium: 30.0 gm. sucrose, 1.0 gm.  $K_2HPO_4$ , 0.5 gm.  $MgSO_4 \cdot 7H_2O$ , 0.5 gm. KCl, 0.01 gm.  $FeSO_4 \cdot 7H_2O$ , 2.0 gm.  $NaNO_3$ , 15.0 gm. agar per liter of distilled or tap water. 2. Nutrient agar: 10.0 gm. dextrose, 5.0 gm. peptone, 3.0 gm. beef extract, 5.0 gm. NaCl, 15.0 gm. agar per liter of distilled or tap water. The pH of the medium was adjusted with NaOH to 7.5 before sterilization. After the dilution plates were poured, they were incubated at room temperature (70-85° F.) from 8 to 30 days to permit the microorganisms to grow. Organisms from single colonies were tested individually by the author's modification of the "cross-streak agar method" (1) for antibiotic activity and pure cultures on agar slants were obtained at the same time.

\* Contribution from Schenley Laboratories, Inc., Lawrenceburg, Indiana.

The majority of the strains of *S. griseus* did not produce streptomycin as indicated by the tests using the cross-streak agar method, shake flasks, and aerated bottles. There was no definite indication of relationship in regard to sporulation, growth, pigmentation, and pigment production, etc., in solid and liquid media, between active and inactive strains of this organism.

#### COMPARATIVE TESTS OF ACTIVE STRAINS OF *S. GRISEUS*

The cross-streak agar method (FIG. 1) has shown the relation of the intensity of activity at different dates of three active strains of *S. griseus*. They were SL-751 (Waksman's No. 4), SL-841 and SL-842 (the latter two isolated by the author from Ohio River mud) and a *Streptomyces* sp. SL-788 which is a chromogenous type and produces a soluble brown pigment. *S. griseus* SL-842 followed by SL-841, SL-751, and SL-788 respectively exhibits the greatest activity as measured by the size of inhibition zone. Culture SL-788 is an entirely different species of *Streptomyces* and does not produce streptomycin, although it gives a bacteriostatic spectrum very similar to those *S. griseus* strains which produce streptomycin. The bacterial testers gradually grew toward the master streak of SL-788 after the first 24 hours, but the size of the inhibition zones produced by *S. griseus* strains remained the same. Culture SL-788 was later found to produce very little antibiotic material.

Figure 2, *A* shows the bacteriostatic spectrum of *Streptomyces griseus* SL-842 (at center) after four days growth to sixteen different testers (cross-streak agar method). It can be noted in *A* that No. 8 (*S. griseus*) was self inhibited; No. 9 (*Bacillus subtilis*, Turtox) and No. 11 (*Bacillus subtilis* SL-923) were totally inhibited. Figure 2, *B* shows the bacteriostatic spectrum of the same SL-842 against two bacterial testers by the flooding or smearing method (1), after four days growth. A gram-negative bacterium was used on one side and a gram-positive bacterium on the other side. It can be noted in *A* that the tester No. 3 (*E. coli* NRRL-B-210) has the same inhibition distance as shown in *B*; the same is true for No. 4 (*Bacillus subtilis* ATCC-6633).

Comparative activity tests using the streak and flooding methods have been run with many other *S. griseus* strains. Tests in sta-

tionary flasks, shaken flasks, and aerated bottle cultures indicated that some strains reached the activity peak in a shorter time than others and that the relative amounts of active material produced varied considerably.



FIG. 1. Comparative bacteriostatic spectra of three active strains of *Streptomyces griseus* to six bacterial testers on different dates. SL-751, SL-841, and SL-842 are three strains of *S. griseus* (streptomycin producers) and No. 788 is a *Streptomyces* sp. Note that *S. griseus* SL-842 is the most active and SL-841, SL-751, and SL-788 follow in that order as measured by the distances of inhibition. The bacterial testers which appear parallel to each other are the same in each plate and are as follows from left to right: *Staphylococcus aureus* ATCC-6538, *Bacillus subtilis* ATCC-6598, *E. coli* NRRL-B-210, *Bacillus subtilis* ATCC-6633, *E. coli* NRRL-B-116, *Bacillus subtilis*, Merck-3R9675.

PROGRESSIVE BACTERIOSTATIC SPECTRUM OF *S. GRISEUS* SL-842 TO SIX TESTERS—INCUBATION AT ROOM TEMPERATURE (75° F.)

*S. griseus* was partially inhibited by five bacterial testers (FIG. 3, plate No. 0). Here the master streak and the testers were

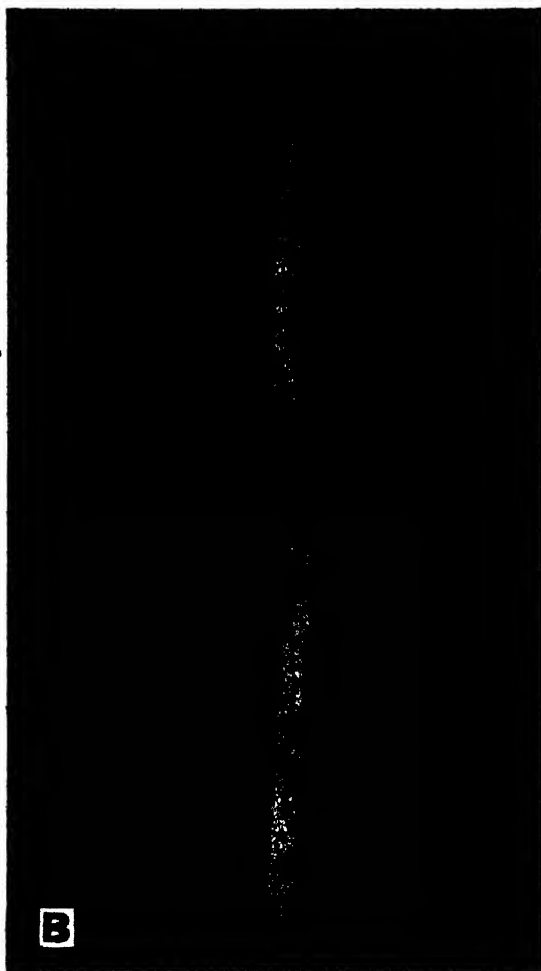


FIG. 2, A and B. Bacteriostatic spectrum of *S. griseus* SL-842 (at center) after four days growth on large plates ( $150 \times 20$  mm.) at room temperature. A, cross-streak agar method and B, flooding or smearing method. The following testers are indicated by the numbers:

- |   |  |
|---|--|
| 1. <i>Staph. aureus</i> ATCC-6538                           | 10. <i>Mycobact. tuberculosis</i> , Turtox                     |
| 2. <i>Bacillus subtilis</i> ATCC-6598                       | 11. <i>Bacillus subtilis</i> SL-923                            |
| 3. <i>E. coli</i> NRRL-B-210                                | 12. <i>Mycobact. tuberculosis</i> var. <i>hominis</i> ATCC-607 |
| 4. <i>Bacillus subtilis</i> ATCC-6633                       | 13. <i>Mycobact. Phlei</i> ATCC-355                            |
| 5. <i>E. coli</i> NRRL-B-116                                | 14. <i>Mycobact. tuberculosis</i> var. <i>bovis</i> ATCC-8420  |
| 6. <i>B. subtilis</i> Merck-3R9675                          | 15. <i>Serratia marcescens</i> , Turtox                        |
| 7. <i>Mycobact. tuberculosis</i> var. <i>bovis</i> ATCC-599 | 16. <i>Bacillus mycoides</i> , Turtox                          |
| 8. <i>Streptomyces griseus</i> SL-842                       |  |
| 9. <i>Bacillus subtilis</i> , Turtox                        |  |

streaked out at the same time and the results were observed after twenty-four hours. In plate No. 1, *S. griseus* was grown for one day and then the testers were streaked out and results noted after twenty-four hours. *S. griseus* produced enough streptomycin to inhibit for a short distance the growth of all six testers. Note also the slight inhibition of *S. griseus* by three testers at the far left.

The numbers 2, 3, 4, 5, 6, and 7 (on fig. 3) indicate that the testers were streaked out after 2, 3, 4, 5, 6, and 7 days of growth of *S. griseus* and the results recorded after 24 hours. All were incubated at room temperature. Note in them the progressively greater inhibition zone of the testers caused by the higher yields of streptomycin which diffuses out in the agar from the master streak.

#### OTHER CHARACTERISTICS

It is an advantage for the production of streptomycin to have rapidly growing strains that sporulate well and produce a thick layer of spores on the surface of the agar. Those strains which produce a thicker layer of spore masses usually have much longer and more ramified spore chains and, therefore, a greater number of spores per unit area than poor sporulating strains. The spore masses of some strains when suspended in liquid, such as sterile water or liquid media, form a more or less uniform suspension after good agitation. Other strains on the contrary form very poor suspensions because the majority of the spores will float in clumps on the surface of the liquid and collect at the sides of the container. It has been found that these less wettable spores are usually covered with small fragments of film. This may be due, in part, to the fact that during normal spore production these

FIG. 3. Progressive bacteriostatic spectrum of *S. griseus* SL-842 (top) to six bacterial testers. Number 0, *S. griseus* and the testers were streaked at the same time. Numbers 1, 2, 3, 4, 5, 6, and 7 indicate that the testers were streaked out after 1, 2, 3, 4, 5, 6, and 7 days of growth of *S. griseus*. The results were observed after 24 hours. The bacterial testers which appear parallel to each other are the same for each plate, and are as follows from left to right: *Staph. aureus* ATCC-6538, *Bacillus subtilis* ATCC-6633, *E. coli* NRRL-B-210, *Mycobacterium tuberculosis* var. *hominis* ATCC-607, *Bacillus mycoides*, Turtox, *Serratia marcescens*, Turtox.

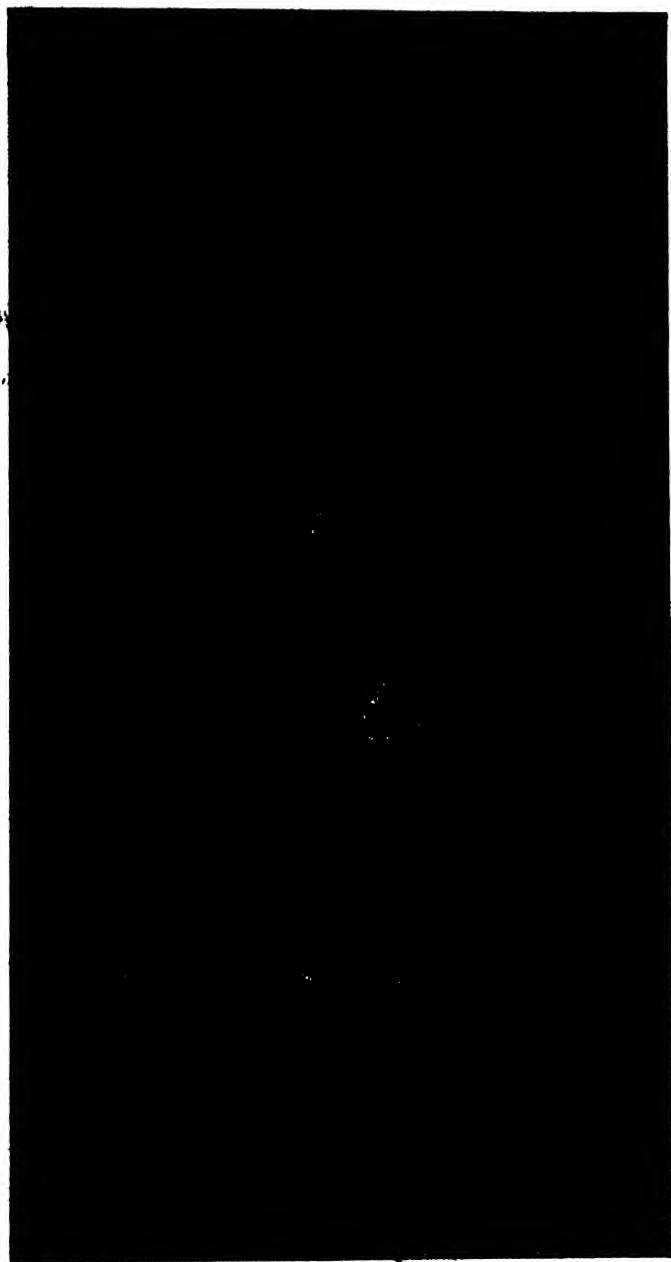


FIG. 3.

strains produce an exudate which, when dried on the outside of the spores, forms a film which may break at several points but still partially adheres to the spores. By constant agitation or warming of the spore suspension, these external particles separate or dissolve from the spores which then go into suspension. These particles, as seen in the electron microscope, appeared as a transparent film. Details of these observations are presented in another publication.

In the course of studies with various media, it was found that the best medium for spore production for one strain may be unsatisfactory for another. Masses of spores of one strain produced on some media gave poor spore suspensions even after good agitation. However, the same strain of *S. griseus* gave a uniform spore suspension with spores produced on another solid medium.

The color and pigment production of strains of *S. griseus* also varies considerably. The aerial mycelium and spore masses of all isolates have a very distinctive buff color with slight variations in intensity. This variation also may be brought about by changing the nutrients, the pH of the medium, temperature, by aging, etc. Some strains produce little or no water-soluble pigment whereas others produce a considerable amount of dark olive-green pigment which diffuses out into the substratum.

The odor produced by strains of this organism grown on organic (plant or animal material) or synthetic media varies considerably. On a given medium, some strains produced a very faint earthy to musty odor whereas others gave a more penetrating odor. The odor was increased markedly in the presence of liver extract.

Variations in the color of the aerial and submerged growth and in the amount of soluble pigment produced are found common to both active and inactive strains. The same is true with the odor produced by these strains.

Colony variability is found among the different strains of *S. griseus* and to a certain extent within groups of colonies derived from the same isolate. Some strains are very stable in their characteristics. Others produce colonies of a rough type with marked and prominent folds, the spore masses of which break up into a chalky powder over the surface of the nutrient agar when dry (FIG. 4, A). Other strains give a smooth or fairly flat type of colony of

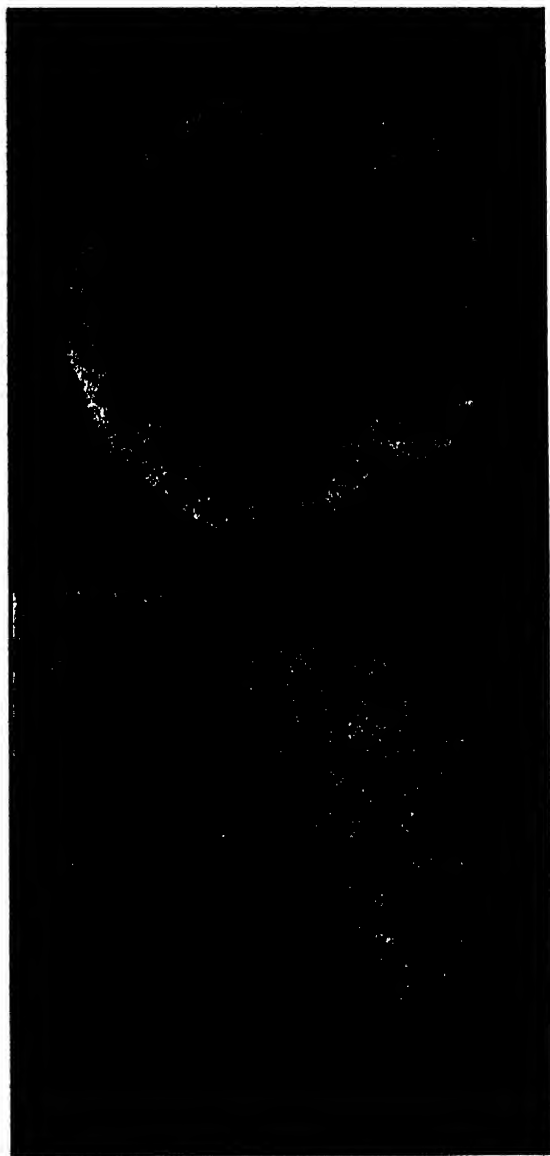


FIG. 4, *A* and *B*. Two colonies of *S. griseus* SL-842 showing different sectors. *A*, is a 3 months old colony reduced half size. *B*, is a one month old colony enlarged 2 times. Note in *B* the concentric rings of growth.



a lighter color which neither forms very extensive aerial mycelium nor has a great amount of sporulation.

Some cultures of *S. griseus* were found to be more unstable than others in their morphological, cultural, and biochemical characteristics. The instability of *S. griseus*, as well as other species of *Streptomyces*, has been demonstrated by several workers (5, 6). The writer, for instance, by making high dilution cultures of spores from *S. griseus* SL-842 obtained three culture types from single colonies which were tested by the cross-streak agar method. They were very similar in cultural characteristics and morphology. The amount of streptomycin and of pigment produced by various strains appeared to be the outstanding differences between them. Most of these strains were equal in activity to the parent culture; a few were slightly less active, and a few were more active than the parent culture. One strain, 842-4, produced less pigment and considerably more streptomycin both in shaken flasks and in deep culture than the parent culture.

By isolating spores from individual sectors produced in isolated colonies or in streak cultures, differences may be found in these cultures when compared with the parent culture. Such variations may be in activity (streptomycin production), rapidity of growth, amount of sporulation, pigmentation, biochemical differences, types of growth (rough or smooth), sterility, etc. Figure 4, A and B shows two colonies of *S. griseus* which produced sectors of various shapes. Two distinct types, which differed from the parent culture, were obtained from separated sectors of old colonies and from streaks. One type which was about equal in activity to the parent culture produced considerable pigment, a pronounced odor, and heavy sporulation. The other type produced very little pigment, odor, or streptomycin, and sporulation was very light.

#### CARE AND STORAGE OF CULTURES

Once a pure culture has been obtained, it is necessary to keep it in good condition and ready for use at any time. It is of capital importance to preserve the morphological and physiological as well as biochemical characteristics of the organism, especially those of cultures which produce large amounts of streptomycin.

A general practice used by the author for several years is the following: Fresh agar slants or other containers are seeded by smearing the entire surface with a heavy spore or cell suspension in distilled sterile water. The spores should be from a young, well sporulated culture. This technique has been found advantageous in the culturing of microorganisms such as Actinomycetes, higher fungi, bacteria, and algae. By means of this method the development of individual and separate colonies is very much reduced. When the spores of *S. griseus* germinate on the nutrient agar, the vegetative growth will form an even mat within a few hours. The entire mycelial surface will then work as a single unit and will promptly start sporulation, thus giving maximum production of spores and less vegetative growth in a shorter period of time. The cultures are allowed to sporulate at room temperature (about 75° F.) on a table receiving subdued light. With vigorously sporulating strains of *S. griseus* on a suitable medium, good spore production is obtained in one to five days. After the cultures are well sporulated, they are stored at 3-4° C. In this way, the microorganisms are kept more stable by retarding the appearance of sterile overgrowths, sectorings, variations and mutations. These methods have been found more satisfactory than that of making transfers to agar slants by means of a streak in the center or by seeding at one point.

#### LYOPHILIZATION OF *S. GRISEUS* CULTURES

The procedure used was basically that described by Wickerham and Andreasen (10). Success has been obtained in the preservation of Actinomycetes. As an example, three different active strains of *S. griseus*, streptomycin producers, were used. Fresh spores were suspended in skimmed milk (made with Difco dehydrated skimmed milk). This suspension after lyophilizing gave an ideal pellet. Several tests for activity, growth, spore production, etc., were made of the lyophilized cultures in comparison with the parent culture, which has been carried on agar slants. Comparative activity tests were made of the three strains by means of the cross-streak agar method, surface, shaken, and aerated bottle cultures. Results showed no difference between the parent and lyophilized cultures. Each strain kept its identity.

## SUMMARY

1. The saprophytic fungus *Streptomyces griseus* has been isolated from soils, river muds, insects, plant roots, air, foodstuff, animal excreta, water, decomposing plant material, and dust.

2. The majority of the strains found were unable to produce streptomycin, but a few did.

3. Active strains varied greatly in their ability to produce streptomycin.

4. When *S. griseus* strains were streaked at the same time, perpendicular to various bacterial testers, they were partially inhibited by some of the bacteria, particularly by *Staphylococcus aureus*, *Bacillus subtilis*, and *E. coli*.

5. Studies were made of the behavior of several active and inactive strains of *S. griseus*. Variations in growth, sporulation, color, soluble pigment production, odor, and other physiological characteristics were found common to active and inactive strains as well.

6. The best sporulating agar medium for one strain may be unsatisfactory for another strain.

7. Colony variation is found among colonies derived from the same isolate. The active strains may be improved by selection and testing individual colonies.

8. Better stability of cultures was obtained by smearing the whole surface of the nutrient agar medium with a heavy suspension of spores rather than by streaking or seeding at one point.

9. Lyophilized cultures of active strains of *S. griseus* were found not to differ from the parent cultures in morphological, physiological, or biochemical characteristics.

The writer wishes to acknowledge the photographic work which was done by Mrs. Marie Lommel and Mr. G. B. Levy.

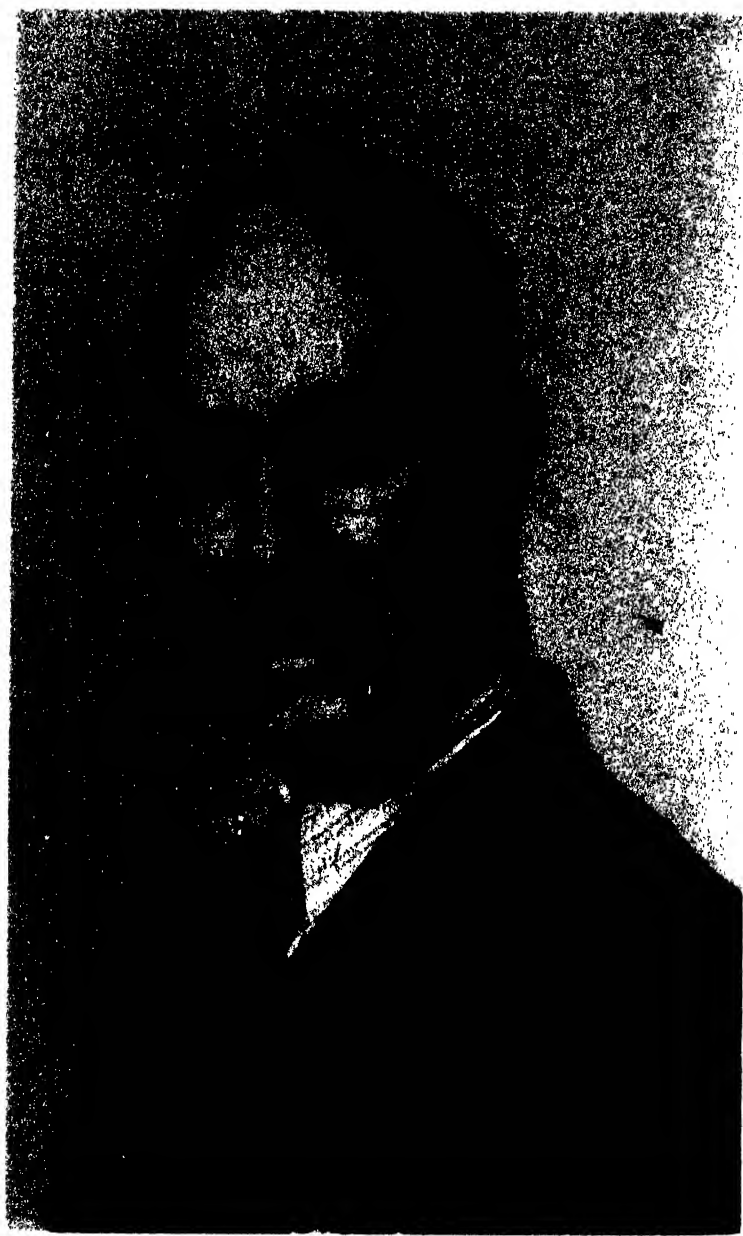
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## SOME BASES FOR MYCOLOGICAL PROGRESS \*

FRANK D. KERN

Progress is a problem which has engaged the attention of many thoughtful men. Nor should we put this only in the past tense for the problem of social progress is now uppermost in the minds of many thinking persons. Lucretius, a Roman of the first century, B. C., is credited with first using the word "progress" in the modern sense of "going ahead" as against "going backward." This has been an ever changing world; in some cases the changes are merely evolution; and evolution, however, is not synonymous with progress.

A friend of mine, who is a teacher of English Literature, recently said that in his search for a common belief among college students, he has found only one first-rate candidate—the belief in progress. He has put it in these words, "Almost all of them have seen a cave-man—in textbooks or movies or comic strips. They can see the difference between themselves and Tarzan at once, the latter ill-clad, uttering wild cries, lacking electricity. Some students also see progress in the strides of science—new inventions, greater speeds, the atom bomb—without inquiring closely about the effects of these newer and faster gadgets. Some see progress in 'the survival of the fittest' and biological slogans. Some see it in books of ancient history. Girls see it in a succession of old

<sup>4</sup> Address of the President, 1945, Mycological Society of America, and of the Vice President of the A. A. A. S. and chairman of the Section on Botanical Sciences, 1945, St. Louis, Missouri; March 28, 1946. Contribution from the Department of Botany, The Pennsylvania State College, No. 154.



styles of dress, most of which are unfamiliar and therefore inferior." He points out that the doctrine of progress has been held by many in an unthinking manner especially in recent centuries. "One can hardly read any writer of prominence," he says, "without finding somewhere a casual mention of human progress as a part of the furniture of his mind."

The philosophical viewpoint is that progress not only consists in performing a function with greater ease or with greater proficiency or more efficiency but also in doing something desirable. The test of desirability is more difficult than that of efficiency. We have certainly developed more effective weapons for war. Being able to kill and to be killed by thousands may prove our efficiency but it is a fair question whether it constitutes progress. "That which is desirable, all things considered, is the final test of progress." Benjamin Franklin in predicting the power of men over matter showed his appreciation of the potentialities of natural science but he was also aware of its dangers as indicated by his plea, "() that moral science were in a fair way of improvement, that men would cease to be wolves to one another, and that human beings would at length learn to know what now is improperly called humanity."

In choosing to discuss "some bases for mycological progress" it was in my mind to present some ideas that might make for progress in the future. But mycology has made much progress since the days of the herbalists of the 17th century. It may assist us in our thinking to review some of the bases for past progress.

An early basis of progress was the microscope. By the time of the publication of Micheli's *Nova plantarum genera* in 1729, the microscope had become a working-aid and the author made use of it. His work was an example of good scientific method for the time. He germinated spores of the larger fungi and observed both the mycelium and the sporophores. Germination of spores of the microfungi was not recorded until much later (1807). Early interpretations of microscopic studies of fungi were based upon the understanding of the parts of flowering plants. "The sporeheads, or large spores, seemed like the fruiting pods of Lilliputian plants, each containing its quota of seeds." DeCandolle thought that the spores of *Uromyces* and *Uredo* contained small grains, or spores. A telio-

spore he thought might contain 100 such "spores." But the advances made with the microscope did not continue uninterruptedly. Fries, during the middle of the 19th century, made great contributions to the knowledge of the larger fungi and developed great prestige. Apparently he did not use the microscope and perhaps that accounts for his poor opinion and antiquated conception of the parasitic fungi.

Another basis of progress was the substitution of the careful study of the orderly development of a few species for the previous method of comparing the gross appearance of many forms. Cultural demonstrations brought about what may be called the life-history concept. They resulted in the recognition of a mycelium as a vegetative body, of the possibility of the production of more than one kind of spore in a life cycle, and ushered in the change from the old to the modern viewpoint. For a real contribution to this kind of progress we are indebted to deBary. These advances were made from 1853-1863.

During the first three quarters of the 19th century new species were being recognized and named from all parts of the world. The descriptions appeared in a variety of journals, reports, and books. Many of these were not widely circulated. It is little wonder that workers soon found it difficult to know whether or not a specimen under consideration was already named. It may well be added that this condition still prevails. I shall return to it later. Thus it happened that many species were named more than once. It has been asserted that many mycologists of those days were deterred "from describing supposedly new species for fear of duplication." That statement may meet with some "eyebrow lifting" but I remind you that I am only quoting. An important step toward overcoming this situation was the publication of the *Sylloge Fungorum* inaugurated by Saccardo in 1882. The immediate effect was the stimulation of systematic mycologic activity. This monumental work continued into twenty-five volumes, the last appearing in 1931. During this period mycological journals made their appearance in various countries and taxonomic work proceeded at a rapid pace.

The next impetus in the study of fungi came from researches on the nucleus and its behavior. These gave a new direction to

mycological advances. As life histories revealed by cultural studies had been recognized as important, so nuclear developments revealed by cytological studies came to be recognized as important. The applications of cytological methods to the study of fungi began with the work of Dangeard in 1894 and soon were under way on a large scale by a host of investigators. In the last few years many genetical studies have been made and highly significant results obtained.

Many diseases of plants are caused by fungous parasites. The great advances in the field of plant pathology have had significant influence upon the development of mycological science. Many species of fungi have been isolated, cultured, and identified, by the pathologists. It is necessary to be able to name the pathogens and taxonomy becomes important.

This is a brief and unsystematic survey of past progress. No attempt has been made to make it systematic. Woodrow Wilson once said that any systematic writing is immoral writing, because no man knows enough about anything to write about it systematically. "No man," he said, "knows more of a certain subject than some parts." In the beginning, I intended to be cautious by proposing to talk about some, not all, bases of mycological progress. In discussing the effects of the microscope, the life-history concept, Saccardo's Sylloge, and cytological and pathological investigations, the intent has been to provide a certain amount of background or perspective. It has been said that perspective is the chief aim of all education, that facts are only scaffolding whereas perspective is the structure itself.

The earliest mycologists were interested in taxonomy. From those early times to the present there have always been some workers who have been interested in describing, naming, and classifying. It is well that morphology, physiology, cytology, and genetics have their devotees—it is also well that there are those who are willing to devote themselves to taxonomy. They say nowadays that a nation cannot advance without a sound economy. We might paraphrase this and say that mycology cannot advance without a sound taxonomy.

It seems worthwhile to present some of the problems which taxonomic workers encounter. This means both the problems

which are inherent in taxonomic studies and also the wider limitations which often operate to check progress and to break the continuity of advances for which a groundwork may have been well established. Taxonomic work in general, as well as in mycology in particular, has a checkered history. Its advances have been piecemeal. Even at the risk of repeating certain things which I have already presented in another paper,<sup>1</sup> I propose to discuss some of the reasons why mycologic taxonomy does make more substantial progress and to present some of the bases for better and more continuous progress in the future. There is danger in this—one may be accused of being too idealistic. But I like to think that Walter Lippman was right when he said, "Ideals are not hallucinations. They are not a collection of pretty and casual preferences. Ideals are an imaginative understanding of that which is desirable in that which is possible." I am also heartened by Bacon's observation that "The light which we have gained, was given us, not to be ever staring on, but by it to discover onward things more remote from our knowledge." Things haven't changed much since Bacon's time for he pointed out that where there is a desire to learn, "there of necessity will be much arguing, much writing, many opinions. . . ." This statement will doubtless be accepted by all, but his further statement that "opinion in good men is but knowledge in the making" will probably be challenged by many.

In the next several paragraphs I am going to quote freely from my previous paper, already mentioned, because I think the sentiments expressed bear repetition and also because I cannot state them any more clearly or forcefully. I might add that I have written abstractly while thinking concretely.

It seems likely that we must depend largely upon institutions to furnish the support for taxonomic mycology. Of course we have not been without interested laymen who have done their work chiefly or wholly without institutional support. To them great credit is due. We should have more of them. The fact remains that we must look to the universities, experiment stations, research institutions, or governmental departments for most of the needed resources. Even where these agencies are involved it is still true

<sup>1</sup> The importance of taxonomic studies of the fungi, *Torreyana* 43: 65-77, 1943.

that the ambition, industry, and perseverance of individual staff members are more responsible for the advances made than are the plans and direction of the administration. We have been hearing a good deal about institutional research but so far as taxonomic work with fungi is concerned we believe an analysis would show that research in this field is chiefly due to individual initiation rather than to institutional planning. It may happen that an institution will make an effort to continue a certain type of research after it has been inaugurated and successfully carried on by one of its staff members and will then refer to the program as an institutional program. More often it happens that a real leader appears and develops successfully a line of work which is supported (more or less) during his years of activity but which is dropped by the institution afterwards. Such instances indicate the correctness of the conclusion that there is often no such thing as an institutional program. There are, of course, exceptions but we feel safe in saying that the exceptions prove the rule rather than make it. We have inserted the parenthetical phrase—more or less—because we are sure that institutional support even when forthcoming during the height of the program is often more apparent than real. Certainly it is true that many of our productive mycologists have had to earn their "bread and butter" with teaching and routine duties and have had left only a small percentage of their time and efforts for the kind of work which they were so well qualified to pursue.

Someone may well ask why these difficulties are raised in connection with taxonomic research when they exist in so many lines of research activity. There are several reasons for this. Of course I need not explain why I single out mycological taxonomy.

The source materials for taxonomic research are in large part not commercial commodities. They consist of specimens, rare books, separates, indexes, and illustrations, which are accumulated only with time, patience, correspondence, and exploration. When such collections have finally been put together in an institution they should be used by more than one generation of workers in that institution. Or, if that is not possible some method should be worked out by which they become available to succeeding investigators in other institutions.

There are now in existence some collections of microfungi where spore measurements and drawings accompany literally hundreds of specimens. Such aids are indispensable for taxonomic studies and when available not only save the time necessary to duplicate them elsewhere but help to prevent errors and misconceptions. There are also herbaria of fleshy fungi where great accumulations of photographs, drawings, and notes make them of the utmost importance to other workers. This is not a plea for the centralization of mycological taxonomy. It is rather to call attention to the fact that enormous resources are frequently accumulated and then neither used nor made available for use. Since our modern concepts fix the application of names by types rather than by descriptions, it is a fair question whether type specimens should ever be personal or institutional property. The difficulties may seem insurmountable but this is not a foregone conclusion. Surely we shall make no progress until the workers themselves reach a keener appreciation of the situation.

There are other factors which bear on the progress of taxonomic work with the fungi. Even though a staff member may have the ability and enthusiasm to carry on work of this sort, it may be, as previously indicated, difficult for him to obtain the full cooperation of his institution. Projects which have more evident economic aspects frequently elicit more favor with administrative officials in publicly supported institutions. This is true in spite of the basic relation of taxonomic studies of the fungi to many phases of plant science, medicine, and industry. It is easy to comprehend why this attitude prevailed in the early days, but it is not so easy to see why the value of fundamental work of this sort has not eventually come to be recognized more generally.

And again, even though there may be institutional approval so far as the time of the worker is concerned, it is often difficult to secure funds for the type of maintenance which is essential for taxonomic projects. For a project requiring special apparatus, machinery, glassware, and chemicals, it is usually not difficult to secure funds. But to secure funds for the purchase of specimens, photographs, particular books, separates, periodicals, indexes, and exploration, may be difficult or well-nigh impossible. It is generally conceded that a research worker is not expected to get along

with the equipment and supplies which are in general stock but is entitled to special expenditures for his project. Not so with library facilities. He may be expected to get along with what the institutional library provides. He may of course compete for more than his share of the general library funds but this is not always satisfactory even if partially successful. The use of research funds for special library facilities is much less common than for special material equipment. The problem of publication is a closely related one. Monographic treatises are often expensive to publish and the demand for them may be slight and slow. The fact that publication is difficult tends to discourage this type of work.

Where, then, is progress? Workers come and go. Change is incessant but are we sure that we are pursuing an upward path? As we have pointed out, the isolation of workers and the attitude of institutions has caused repetitions upon a grand scale as well as upon a small one. In order to get going, an individual must spend much time doing things that have been done before and accumulating material that already has been accumulated elsewhere. Perhaps that is the way of the world and it must be so. Marcus Aurelius said that although there is continual change everywhere, it runs in cycles and does not escape their confines. The social scientists put it another way. They recognize the repetitions through the whole of history and refer to the same dramas, with the selfsame scenes reproduced, with merely a change of actors.

Coming now to the problems of mycological taxonomy, is there anything that we can do to avoid the necessity of so much unproductive repetition? What can we do about valuable things that are no longer being used and yet not available? Individuals and institutions must be physically separated, but can they not be brought scientifically closer together?

I propose that we should have a national mycological institution. I have not gone so far as to draw up a charter or a constitution. Neither have I tried to solve the problem of support. It seems safe to assume in these days of the wide interest in research on a national scale that both public and private funds could be had if the Mycological Society of America would determine what sort of an organization is desirable.

I am not proposing a new research institution. What I have in

mind is an institution in the nature of a bank, or clearing house, which would have on deposit a wealth of scientific resources—specimens, indexes, separates, and other aids—and perhaps even money. Neither am I proposing cooperative research but rather cooperation in research, a very different matter.

First of all there would be constituted a national mycological herbarium. Operation as such, and not as a part of any of the government departments, should enable it to play a role not now played by any other herbarium. I have already said that it seems a fair question whether a type specimen should ever be regarded as private property.<sup>2</sup> But as long as there is no real public "treasury" in which to deposit them, they are likely to remain in their place of origin. Of course they can now be sent to any of the large herbaria but incentive to do so is not very great and certainly pressure to do so is lacking. Fortunately material of many mycological specimens is divisible so that portions of types could be furnished by an author if he felt the urge. It should not be left to chance. The kind of national organization I have in mind would immediately contact authors of new species. I believe the response would be excellent. And the campaign for type specimens should not be limited to solicitations within our own country, but should be world-wide. If actual specimens were not obtainable there are possibilities of photographs, drawings, and special notes. It has been well said that considering types are one of the basic assets of botanical science, the complacency of American botanists toward them is indeed remarkable.

It seems safe to conclude that a national institution could become without doubt a repository for many privately organized collections which are no longer in the hands of the originator and are not being used by a successor. Acquiring such collections by loan, provided they could not be obtained by title, would help much.

<sup>2</sup> After writing this, my attention has been drawn to a similar statement by F. R. FOSBERG in *Science* 89: 245 (1939), "Types and other historic specimens can no longer be regarded as the private property of individuals or institutions, but must be treated as a legacy, entrusted to us by the botanists of the past for the benefit of botanical science, present and future." The same author has presented well the case for the necessity of segregating and safeguarding type specimens at all times and especially during the dangers of war. See *The Journal of Botany*, November, 1938, pp. 327-330, and *Science* 96: 515-516 (1942).



The staff in this national institution should be able to keep up indexes of literature on a scale beyond that possible for individuals or for most institutions. Without a current Saccardo many workers need help with taxonomic literature. Interlibrary loans, once simple and direct, are now difficult and restricted. This general reference to mycological literature leads naturally to the subject of publication. Monographs are frequently long and with illustrations; the expense of publication may be great in comparison with any possible income from sale. I know of two such manuscripts which should be published but which cannot find a commercial or institutional publisher. This mycological bank we are talking about should have money in it for such good work.

It should have money also to aid in sending representatives to International Congresses, especially if rules of nomenclature are to be considered. Most of you know that we must have international rules of nomenclature. The only way so far devised to secure such rules is through International Congresses. As far as I am able to learn most of the delegates "delegate" themselves. By that I mean that societies and organizations appoint as delegates those who have decided to attend on their own. The representatives are, therefore, not necessarily those best qualified to take part in such important proceedings, but rather those who are able or at least willing to finance the trip themselves. I wonder what would be the outcome if our national government selected delegates on such a basis to other international meetings where matters affecting the welfare of the nation are under consideration.

After considering the problems of progress in general and the bases of progress in mycology in particular, both historically and with regard to future developments, I am reminded of the story of the two little girls who were comparing progress in catechism study. "I've got to original sin," said one. "How far have you got?" Said the other: "Oh, I'm way beyond redemption." That seems to be the place where this discussion should end today but I hope it will be continued by the Society and that further progress along the lines suggested will not be too long delayed.

# STUDIES IN THE GASTEROMYCETES XIV. THE GENUS CHLAMYDOPUS

W. H. LONG AND DAVID J. STOFFER

(WITH 7 FIGURES)

The tribe Phellorineae consists of three closely related, cosmopolitan, monotypic genera, *Phellorina* Berkeley, *Dictyocephalos* Underwood and *Chlamydopus* Spéggazzini. These three genera have sporocarps elevated at maturity on a definite, elongated stipe, basidia in fasciculate clusters persistent at maturity, pulverulent gleba and colored, continuous, verrucose spores. The endoperidium in each genus consists of two distinct structures, a permanent outer basal region formed by the expanded modified stem-apex and an inner layer lining the entire glebal cavity. In *Dictyocephalos* the dilated stem-apex portion of the endoperidium becomes hard and leathery with age (Long & Plunkett, 1940). It may be a mere rim or collar around the base of the sporocarp, or extend upward 2-3 cm. as a very irregular, jagged, saucer-like wall whereas the inner lining continues beyond the leathery basal part as a thin membrane, covering the entire gleba, and is shed on dehiscence. The leathery, basal part remains permanently attached. In *Phellorina* the expanded stem-apex forms an urceolate leathery permanent endoperidium for two thirds to five sixths of the length of the sporocarp leaving a small top part of the gleba covered only by the membranous inner layer, which falls away during dehiscence. In *Chlamydopus* the endoperidium completely covers the gleba and on maturity develops an apical stoma.

## KEY TO THE THREE GENERA

1. Exoperidium continuous with stipe, endoperidium an urceolate expansion of the stem-apex..... *Phellorina*
2. Exoperidium not continuous with stem, sporocarp seated on the expanded stem-apex, stem volvate.....3
3. Gleba cellular, dehiscing by the irregular breaking away of the peridium  
*Dictyocephalos*
3. Gleba not cellular, dehiscence by an apical stoma.....*Chlamydopus*

## CHLAMYDOPUS Spegazzini

An. Mus. Nac. Buenos Aires 6: 189. 1899

*Sporophore* hypogeous, enclosed in a volva or universal veil during early stages of growth, erumpent at maturity. *Peridium* double; the *universal veil* breaking away in pieces. *Endoperidium* coriaceous to membranous, tough, dehiscing by an apical stoma. *Stipe* dilated at apex, not socketed, long, stout, becoming woody. *Gleba* powdery, having capillitium, spores and fasciculate basidia. *Columella* none. *Spores* globose, colored, continuous, usually verrucose. *Basidia* bearing 1 to 4 spores apically on short sterigmata.

TYPE SPECIES: *Tylostoma meyenianum* Klotzsch.

DISTRIBUTION: North America; South America; North Africa; Australia.

CHLAMYDOPUS MEYENIANUS (Klotzsch) Lloyd, Myc. Writ. 1: 134-135. 1903.

*Tylostoma meyenianum* Klotzsch, Nov. Act. Caes. Leop. Carol. Nat. Cur. 19: 243. 1843.

*Tylostoma deserticola* Philippi, R. Florula Atacamensis p. 130 (p. 50 of reprint). 1860.

*Tylostoma maximum* Cooke & Massee, Grevillea 15: 94. 1887.

*Chlamydopus clavatus* Speg., An. Mus. Nac. Buenos Aires 6: 189. 1899.

*Chlamydopus amblaiensis* Speg., *ibid.* 1899.

*Tylostoma clavatum* Sacc. & Sydow, Syll. Fung. 16: 234. 1902.

*Tylostoma amblaiense* Sacc. & Sydow, *ibid.* 1902.

*Sporophore* originating 3-8 cm. below the surface of soil. *Sporocarp* subglobose to depressed-globose to rarely slightly concave at base, 5-18 mm. tall by 10-30 mm. wide, firmly attached to the dilated stem-apex. *Exoperidium* none (excluding the universal veil). *Endoperidium* membranous-subcartilaginous, tough, persistent, pinkish buff to pinkish cinnamon, smooth. *Collar* none, or on some plants a pseudo-collar formed by the rupturing of the cortical layer of the stem at base of peridium. *Mouth* apical, plane, indefinite, 0-6 mm. in diameter, often enlarged and irregularly lacerate in age. *Stipe* 4-15 cm. long by 2-15 mm. thick at top by 1-10 mm. thick at base, woody to corky, solid or rarely with a small central cavity, context more or less porous, curved, terete or angular, often flattened, especially the upper half, longitudinally sulcate or rarely smooth, attenuate below, scales fibrillose-silky to flat-appressed, or none, cartridge buff to cinnamon, a few pecan



FIGS. 1-2, *Chlamydopus meyenianus*  $\times 1$ . Fig. 1, volva-cup and false exoperidium; fig 2, type of "*Tylostoma gracile*" White.

brown with extreme age. *Volva* a universal veil, bizonate, dehiscence circumscissile along the equator, upper portion of volva or volva-cap thin, membranous, very fragile and brittle, verrucose (FIGS. 1 & 3), warts coarse, usually  $2 \times 2$  mm. thick, quadrangular, normally deciduous in pieces as the stipe elongates, but sometimes this verrucose cap remaining on the endoperidium as a false exo-

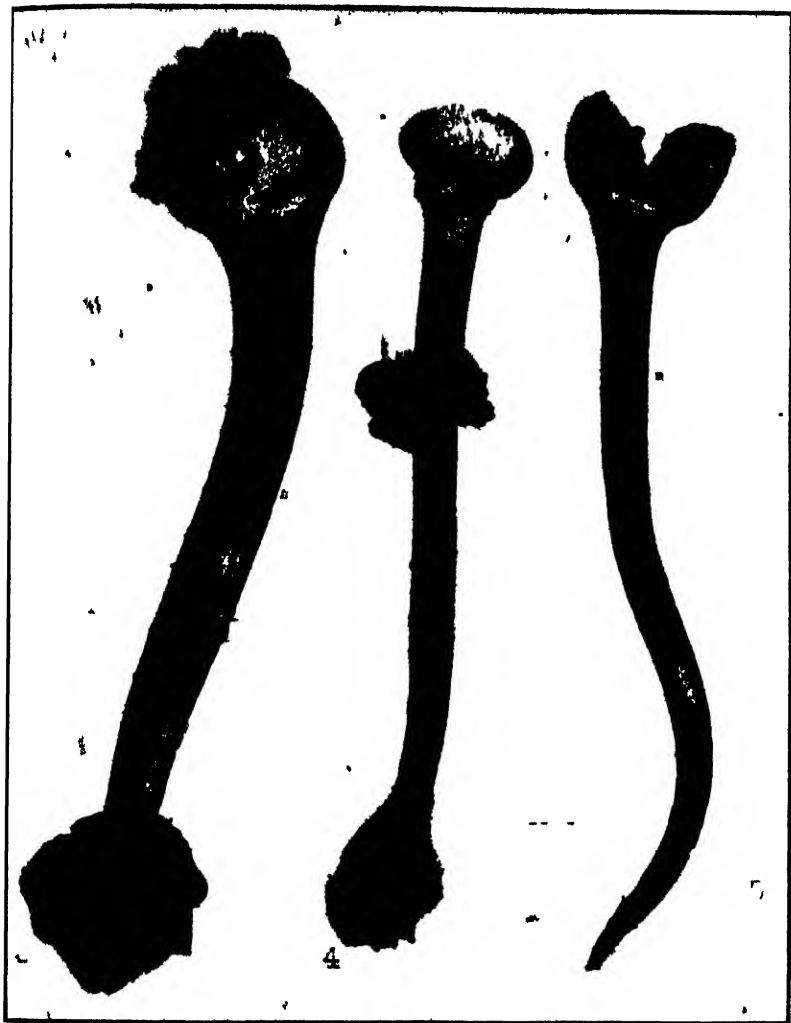
peridium (FIGS. 1 & 3), inner surface of volva-cap buff pink, outer surface pecan brown to walnut brown, warts dingy white; the lower half or volva-cup smooth externally, two-layered, of coarsely chambered tissue, obovate to cupulate to subcylindrical, persistent, 9–12 mm. tall by 10–20 mm. wide at top, walls 1–2 mm. thick, outer layer thin, membranous, inner layer thick, often rotting away leaving the outer coat a thin tough membrane covered with dirt. *Annulus*, rarely a pseudo-annulus occurs (FIG. 4) formed of the remains of the volva-cap which on elongation of the stem were left on the upper part of the stem simulating a true annulus, breaking into pieces and soon deciduous, leaving a normal stipe with no signs of any annulus ever having been present. (A somewhat similar universal veil or volva is found in *Battarreia laciniata* [Long 1943], where the outer volva is triplex having three different zones of tissue.) *Radicating base* none. *Gleba* ferruginous to Hay's russet. *Capillitium* hyaline to slightly tinted, not abundant (in specimens at hand), threads not as well defined as in *Tylostoma*, flaccid, 3–5  $\mu$  thick, septa not seen. *Spores* globose, uni-guttulate, 5.6 to 7.5  $\mu$  usual size 7  $\mu$ . *Epispore* fulvous, moderately but not densely echinulate, rarely smooth.

TYPE LOCALITY: South America near Arequipa, Peru.

ILLUSTRATIONS: Klotzsch, Nov. Act. Caes. Leop. Carol. Nat. Cur., fungi of Meyen Collections, tab. 5, fig. 4. Lloyd Myc. Writ. 1: The Genera of Gasteromycetes, pl. 2, fig. 20, p. 14; Lloyd Myc. Writ. 1: pl. 10, figs. 1–3; Lloyd Myc. Writ. 1: The Lycoperdaceae of Australia, New Zealand and Neighboring Islands, fig. 6, p. 9. Cunningham, the Gasteromycetes of Australia and New Zealand, pl. 29, fig. 1, and pl. 36, fig. 53. White, The Tylostomataceae of North America, pl. 35, figs. 1–6. Spegazzini, An. Mus. Nac. Buenos Aires 6: pl. 4, fig. 2, and fig. 3 as *Chlamydopus amblaiensis* l. c.

HABITAT: usually solitary, in sandy, sand-clay, or volcanic soil, on sand dunes, and in gypsum flats; in the open or usually in partial shade of desert vegetation; in arid or semiarid regions.

DISTRIBUTION: NORTH AMERICA. **Arizona:** Pima County, near Tucson, elevation 2400 ft., C. L. Shear, April 13, 1901, in Herb. Bureau of Plant Industry (1 plant). **California:** San Bernardino County, near San Bernardino, elevation 1080 ft., O. A. Plunkett, comm. Warren Travell, March 1929, in University of California Herbarium at Berkeley, 506660 (1 plant). Western Mohave Desert, I. M. Johnson, in Lloyd Myc. Coll. 5623 (1 plant). Riverside County 6–8 miles beyond Indio, elevation 20 ft. below sea level. H. E. Robert, spring of 1940. Herb. Bureau of Plant Industry, in Morse



FIGS. 3-5, *Chlamydopus meyenianus*  $\times 1$  Fig 3, volva-cup and pseudo-exoperidium, fig. 4, plant with false annulus, fig 5, plant from type locality in Peru.

Coll. 650 (1 plant). Mohave Desert, Los Angeles County, Lancaster, elevation 2350 ft., *Mildred Stein*, May 1940, in Morse Coll. 650 (1 plant) New Mexico: Dona Ana County, Mesilla Park, elevation 3865 ft, *W. A. Archer*, April 10, 1915, in Lloyd Myc. Coll. 5628 (2 plants). *E. O. Wootton*, April 1910, in Lloyd Myc. Coll. 5640 (2 plants), *T. D. A. Cockerell*, May 1898, in New York Botanical Garden (several plants); on mesa north of

A. & M. College, *F. Garcia*, comm. *E. O. Wootton*, April 1894, no. 101 Herbarium of A. & M. College (1 plant), now in the New York Botanical Garden under the name *Tylostoma gracile*; *F. Garcia*, comm. *J. B. Ellis* (1 plant), in New York Botanical Garden under the name *Tylostoma compacte*; on mesa, 1 mile N.E. of A. & M. College, *Clay Smith*, comm. *H. L. Barnett*, April 1941, 9956 Long Herb. (1 plant). Jornada Experimental Range about 28 miles east of Las Cruces on Highway 70, elevation 4150 ft., in open areas between the mesquite-sand dunes, *Ivan H. Crowell*, February 6, 1937, 8156 (1 plant); *W. H. Long* and *David J. Stouffer*, Sept. 8, 1941, 9607 (1 plant). Chavez County, in oak shinnery (*Quercus Harvardii*), 34 miles east of Roswell on Highway 380, elevation 3400 ft., *W. H. Long* and *David J. Stouffer*, April 19, 1942, 10083 (2 plants). Lincoln County, 8 miles south of Oscuro, elevation 5500 ft., *David J. Stouffer* February 20, 1942, 10021 (5 plants), October 27, 1942, 10271 (1 plant); *W. H. Long* and *David J. Stouffer*, April 18, 1942, 10101 (27 plants). Otero County, White Sands National Monument, elevation 4250 ft., in gypsum flats, west of first gypsum dune, one-quarter to one-half mile N.W. of Administration Buildings, *E. Ray Schaeffner*, August 15, 1941, 9686 (1 plant), August 30, 1941, 9958 (4 plants); *W. H. Long* and *David J. Stouffer*, September 13, 1941, 9646 (56 plants); *W. H. Long*, April 22, 1942, 10114 (87 plants). Luna County, 10 miles west of Deming on Highway 70, elevation 4300 ft., in mesquite-sand dunes, *W. H. Long* and *David J. Stouffer*, September 9, 1941, 9614 (1 plant), 11054 (7 plants); *W. H. Long*, April 24, 1942, 10061 (10 plants). Valencia County, 4 miles south of Belen bridge on Highway 6, elevation 4785 ft. in sand-clay soil on *Artemisia* areas, September 18, 1941, *W. H. Long*, 7679 (2 plants); *W. H. Long* and *David J. Stouffer*, December 6, 1941, 9919 (3 plants). Washington: Franklin County, Pasco, elevation 381 ft., in deep sand dunes, *C. V. Piper*, May 20, 1899, in Lloyd Myc. Coll. 5625 (3 plants).

**SOUTH AMERICA.** Peru: Province of Arequipa, near Arequipa, elevation 8000 ft., in volcanic soil, at the base of the active volcano Misti, *P. J. F. Meyen*, in Berlin Museum as *Tulostoma meyenianum*, type locality. Yura, about 20 miles N.N.W. of Arequipa at base of extinct volcano, Chachani, elevation 8000 ft., *Karl P. Schmidt*, August 7, 1939, in Chicago Museum of Natural History, 1,014,666 (1 plant). Chile: Atacama Province, Desert of Atacama, between Cachinal de la Sierra and Agua de Profetas, elevation 9000 ft., *R. Philippi* No. 419 (several plants) as *Tulostoma deserticola*. Argentina: Province of Patagones, near Carmen de Patagones, in sand dunes near seashore, *Carlos Spegazzini*, September 1897, and February 1898, as *Chlamydomys clavatus*, type locality for genus; Salta Province near Amblaio, in very arid sandy hills, elevation 8200 ft., *Carlos Spegazzini*, January 1897, as *Chlamydomys ambliensis*; Mendoza Province, in preandean hills of Potrerillos, near Mendoza, elevation 4500 ft., *Carlos Spegazzini*, March 1910, No. 1260, abundant, as *Chlamydomys meyenianus*. Vicinity of Mendoza, Carnegie Institution of Washington, New York Botanical Garden, Explorations in South America, *J. N. Rose* and *P. G. Russell*, September 1915, 21473 (1 plant) as *Tylostoma* sp.

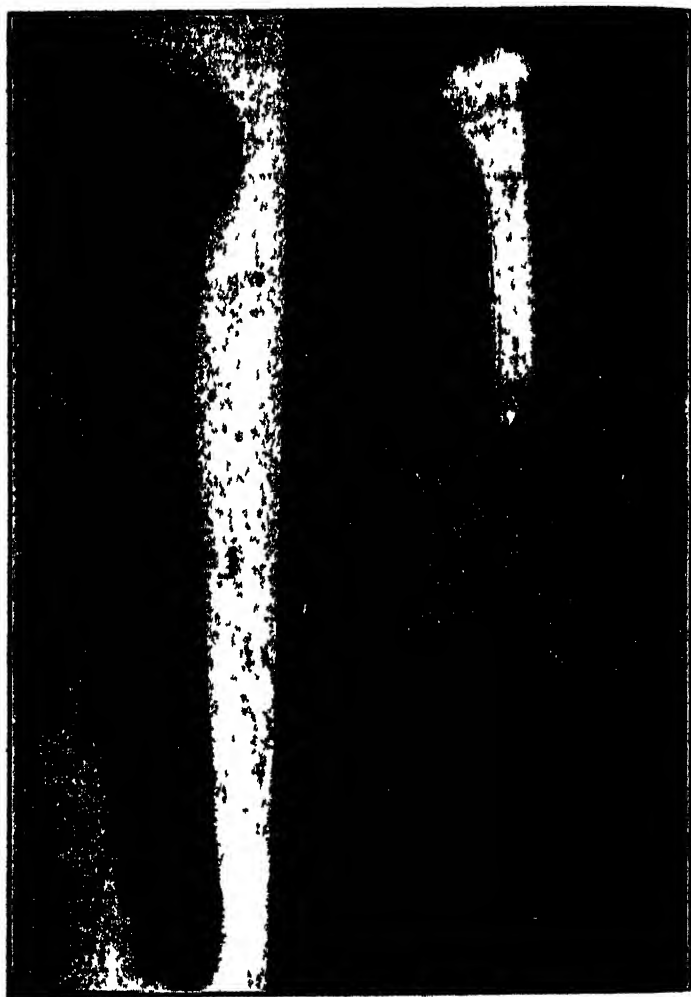
**NORTH AFRICA:** One specimen at Kew under name *Battarreia guicciardiana* (according to Lloyd l.c.).

AUSTRALIA. **Western Australia:** Kalp, J. B. Cleland (his no. 357), Lloyd Myc. Coll. 5631 (1 plant); Kalgoorlie, Gascoyne River, M. Gribble, June 1917, as *Tylostoma maximum*; Kurrawang, Mrs. A. F. Cleland, July 1918. **South Australia:** Millers Creek, Dr. Campbell, August 1921; Minnie Downs, L. Resse, July 1926; Mr. Diets, no locality given; **Victoria:** Miller, Mallee; Walpeup; Pink Lakes, Mallee near Underbool.

The altitudes and habitats for Australia are not available. All the collections listed from New Mexico are in the Long Herbarium at Albuquerque, N. M., unless otherwise stated. The above distribution shows that *Chlamydomus meyenianus* has a wide range in altitude and habitat. In South America this fungus extends from the shore of the Atlantic Ocean in Argentina, inland to elevations of 7000 to 8200 ft. then over the Andes to Peru at 8000 ft., thence up the west coast to Chile where it occurs at 9000 ft. in the Atacama Desert; thus it is rather widely distributed on both slopes of the Andes at high altitudes. In North America, *Chlamydomus* ranges from Southern California, eastward to New Mexico then North to southeastern Washington, with altitudes from 20 ft. below sea level to 5500 ft.

**HABITAT:** In South America this fungus is found on sand dunes, on rocky soil and in volcanic debris. In North America it has a wide variety of habitats, as follows: East of Roswell it grows on low sandhills in a remarkable forest of dwarf oaks which rarely grow taller than three feet; in the Oscuro area it grows on the tops and sides of mesquite-sand dunes in the partial shade of the mesquite trees. In the White Sands National Monument, the plants were found in gypsum flats in the partial shade of *Atriplex canescens*, *Lepideus alyssoides* and *Chrysothamnus latiscameus*. These gypsum flats are small valleys entirely surrounded by gypsum dunes (hydrous calcium sulfate) which have no drainage outlets, hence the soil is heavily impregnated with gypsum from rain water and from wind-blown particles of gypsum settling in the flats. The Jornada area consists of high mesquite-sand dunes with deep depressions between the dunes, the *Chlamydomus* grows in open spots in the depressions. The Deming area consists of low mesquite-sand dunes where the mesquite trees are small (4-8 ft.). This fungus grows on the sides and tops of the dunes, especially on dunes where the mesquite brush is dead or dying; the soil of this area has much clay in it. In the area southeast of Belen the fungus





FIGS. 6-7, *Chlamydopus meyerianus*  $\times 1$  Fig 6, a very large obese form, fig 7, plant from gypsum flats with large bulbous base of rootlets, hyphae and soil.

grows on low hills in a heavy sand-clay soil covered with *Artemisia bigelowni*.

Figure 7 shows the characteristic basal growth of *Chlamydopus* in the gypsum flats of the White Sands National Monument. The

majority of the plants have this large bulbous base, which is composed of rootlets of adjacent vegetation mixed with a mass of white hyphae, grains of sand and gypsum. At first we thought this was an example of root stimulation due to the *Chlamydopus* as described by Shantz and Piemeisel (1917) where they cite instances of stimulation of vegetable growth from "Fungus Fairy Rings," but a critical study of these bulbous formations led us to doubt that such an explanation was correct. These bulbs are unusual in that they are found around the volva-cups extending up on the base of the stems where the volva-cap had been; the rootlets and fungus hyphae are also in the sand which filled the volva-cups after stem elongation. The sporocarps and volva-caps are entirely free of rootlets, hyphae and sand particles, in other words the bulbs are limited to the volva-cups and adjacent portions of the stem. All of the volva-cups found on this gypsum area are filled with rootlets, hyphae and sand; also many stems have rootlets protruding from that portion buried in the soil, indicating that this peculiar bulbous formation originated *after* stem elongation.

Most of the rootlets under the microscope show a multitude of hyphae radiating in all directions from them, but many of the rootlets have masses of hyphae parallel to them. Apparently as soon as the stem elongates, the rootlets and hyphae become active filling the soil inside and outside of the volva-cup thereby producing the globose bulb. If this white fluffy mycelium originated from the *Chlamydopus* then why wait to grow until the universal veil is ruptured, if this white fungus is not a part of the *Chlamydopus* mycelium then again why wait till elongation to become active? These bulbous masses around the volva-cups (FIG. 7) occur only on *Chlamydopus* plants growing in the gypsum area, none were found on any plants growing in other areas (FIGS. 1 & 3). The gypsum evidently is the cause of this bulbous growth. It seems that the *Chlamydopus* plants in the presence of gypsum gives off substances which attract the rootlets of green vegetation as well as attracting the fungus hyphae. Special efforts were made to find the "egg" stages of *Chlamydopus* but none were found, hence we have only old and more or less weathered plants for study. Many of these questions would be answered if we could get the "egg" stages in the gypsum soil. According to Cunningham (l. c.), the

"egg" and stems of *Chlamydozus* have a gelatinous matter in them before elongation, if such is true for our plants then this gelatinous material, or what was left of it after elongation, might be the attraction for the rootlets and the white fungous mycelium, if so, then why do not plants of *Chlamydozus* everywhere have this bulbous base? But, as previously stated, these bulbs are limited to the gypsum areas.

Cunningham (l. c.) finds plants in Australia with stems 35 cm. long and states that these "large specimens may possess a compound peridium when the glebal chamber is divided into several smaller chambers. The top of the sporocarp then becomes somewhat pitted, the depressions corresponding with the positions occupied by the various peridial walls." We do not find any plants with stems longer than 15 cm. nor any with compound peridia as described by him. If this species were not so distinctive, some "splitters" might easily make a "new species" of the plants with these long stems and compound peridia. We have a similar possibility in *Dictyocephalos* (Long & Plunkett, l. c.) where the amazing variations in size, shape, scales and other characters are so many that numerous "new" species could be made from aberrant individuals by writers who believe such characters are valid criteria for differentiating species. The description of *Chlamydozus* given here was made from New Mexico material.

#### DISCUSSION OF SYNONYMS

*Tulostoma meyenianum* Klotzsch (1843) was the name for the original type material collected in Peru by Meyen on which is based *Chlamydozus meyenianus*.

*Tulostoma deserticola* Phil. (1860) is a name applied to our plant found in the desert regions of Atacama in Chile.

*Tylostoma maximum* Ck. & Mass. (1887) was found in Australia but is identical with our plant according to Lloyd (l. c.). The above species were named before the genus *Chlamydozus* was erected.

*Chlamydozus clavatus* Speg. (1899) is the name given to a South American collection from near the shore of the Atlantic Ocean; the author overlooked the older name *T. meyenianum*.

*Chlamydozus ambliensis* Speg. (1899) is the name given to plants which show an annulus, but this so-called annulus is nothing

more than the remnants of the volva-cap left on the stipe during elongation (FIG. 4) and soon disappears.

## ACKNOWLEDGMENTS

We are under many obligations to the following for furnishing data on the specimens of *Chlamydomys* in their respective institutions: Dr. Fred J. Seaver, Mr. John A. Stevenson, Dr. David H. Linder and Dr. Lee Bonar; to the Chicago Museum of Natural History for the photograph for figure 5; to Dr. Karl P. Schmidt of the above institution for valuable data on the climate and topography of the region around Arequipa in Peru and to the National Park Service for permission to investigate the fungus flora of the White Sands National Monument.

ALBUQUERQUE, N. M., AND HOLBROOK, ARIZONA

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# ADDENDA TO THE GENERA *HELICOGLOEA* AND *PHYSALACRIA*

GLADYS E. BAKER

(WITH 25 FIGURES)

Since the publication of descriptions of the genera *Helicogloea* (Baker, '36) and *Physalacria* (Baker, '41), additional material of both genera has been available for study. For each genus the geographical range of the known species is extended and new species recognized.

For *Helicogloea* the geographic range and habitats of previously known species are considerably broadened. Four species are clearly defined as new. A key to all the species is included therefore. Of the eleven species now comprising the genus ~~but~~ but two, *H. sphaerospora* and *H. indica*, have been seen. Descriptions of these have been taken from the original accounts (Möller, '95 and Boedijn, '37, respectively). The genus falls naturally into two lines depending upon the character of the fructification, which may be of the mucous-gelatinous ("tow-like") type, or the distinctly floccose (hypoclinoid) type. Other diagnostic criteria include the position of the basidial primordium which may be apical or intercalary, the character of the hypobasidial sac, the origin of the epibasidium, and the spore characteristics.

## KEY TO THE SPECIES OF *Helicogloea* PAT.

1. Fructification mucous-gelatinous.....4
1. Fructification floccose, hypoclinoid.....2
2. Origin of basidium (primordial cell) apical; hyphae without clamp connections or coils; spores sphaeroidal.....*H. sphaerospora*
2. Origin of basidium usually intercalary; clamp connections present; hyphae freely coiled at times; spores ovoid.....3
3. Hypobasidial sac very irregular, constricted or forked; epibasidial origin from the apex or sub-apex of the primordial cell; hyphae not coiled; spores  $15-19 \times 9-13 \mu$ .....*H. pinicola*
3. Hypobasidial sac constricted but not forked; epibasidial origin usually from the apex of the sac; hyphae conspicuously coiled, especially the free ends; spores  $12-15 \times 7.5-9 \mu$ .....*H. contorta*

4. Basidial origin either apical or intercalary, usually with a sac.....5
4. Basidial origin lateral on a short branch, or both apical and intercalary in the same species.....6
5. Hypobasidial sac small, under  $20\mu$  in length, regular in form; spores ovoid,  $8-12 \times 5-8\mu$ .....*H. graminicola*
5. Hypobasidial sac larger, usually over  $20\mu$  in length.....7
6. Basidial origin a short lateral branch; hypobasidial sac present, pendulous; spores one-celled, arcuate to crescent-shaped,  $24-31 \times 9-11\mu$   
*H. indica*
6. Basidial origin both apical without a sac and intercalary with a sac; spores ellipsoidal to elongate-ellipsoidal, concave, one-, rarely two-celled,  $14-24 \times 5.4-9\mu$ .....*H. intermedia*
7. Fructification usually a thin mucous-gelatinous film.....8
7. Fructification a well-developed, irregular pulvinate mass, several mm. thick; spores subellipsoidal, often a little flattened or concave,  $15-17 \times 6-7.7\mu$ .....*H. caroliniana*
8. Basidial origin apical or intercalary; hypobasidial sac always present; spores ovoid-ellipsoidal.....9
8. Basidial origin usually intercalary; hypobasidial sac sometimes replaced by swelling of the primordial cell; spores subellipsoidal and curved, apiculus very stout,  $13-15 \times 4.5-7.5\mu$ .....*H. longispora*
9. Fructifications pallid to straw-colored; basidial origin usually apical; epibasidium primarily from the apex of the primordial cell.....10
9. Fructification a distinct yellow to orange color when dry; origin of basidium intercalary, sometimes catenulate; epibasidium primarily from the apex of the sac; spores elongate-ovoid,  $16-25 \times 8-15\mu$ .....*H. aurea*
10. Spores ellipsoidal, one-celled,  $8-25 \times 4-13\mu$ .....*H. Lagerheimi*
10. Spores ovoid, 1-3 septate,  $15-18 \times 7-8\mu$ .....*H. inconspicua*

HELICOGLOEA LAGERHEIMI Patouillard, Soc. Myc. Fr. Bull. 8: 121. 1892.

*Saccoblastia ovispora* Möller, Protobasidiomyceten, Bot. Mitt. 8: 16. 1895.

*Saccoblastia sebacea* Bourdot and Galzin, Soc. Myc. Fr. Bull. 25: 15. 1909.

*Saccoblastia sebacea* var. *vulgaris* Bourdot and Galzin, Hym. de France, p. 5. 1928.

*Saccoblastia sebacea* var. *pruinosa* Bourdot and Galzin, Hym. de France, p. 5. 1928.

*Helicobasidium inconspicuum* v. Hoehn. (Fragm. Myk., No. 175), Sitzungsab. Akad. Wien 117, Abt. 1: 1021. 1908.

This is the type species of the genus. New materials from California and Colombia represent the first collections from those areas. Both are quite typical of the species, but that of the former collec-

tion is particularly abundant and striking. A specimen of von Hoehnel's labelled *Helicobasidium inconspicuum* shows the characteristic hypobasidia, apical germination of the primordial cell, and spores of *H. Lagerheimi* Pat., thus reducing it to synonymy with that species.

**HABITAT:** aspen, birch, beech, maple, pine, poplar, and various undetermined woods; humus; sawdust.

**DISTRIBUTION:** Brazil: Rio Grande do Sul, São Leopoldo; Ecuador: Chorrera de Agoyan near Baños; Colombia: Dept. Magdalena, Sierra Nevada de Santa Marta; Canada: Ontario; U. S.: California, Iowa, Missouri; France: Allier, Aveyron, St. Guiról, Tarn, St. Priest-en-Murat, Orne; Austria: Wiener-Wald.

**SPECIMENS EXAMINED:** Colombia, Dept. Magdalena, Sierra Nevada de Santa Marta, vicinity of Dos Aguas, east of Hacienda Cincinnati, elevation 1400-1500 m., August 14, 1935, *G. W. Martin* 3373, ex herb. G. W. M.; Canada, Ontario, Paradise Bay, L. Timagami, August 22, 1935, *R. Biggs* 8499, det. G. W. Martin, ex herb. U. Toronto; August 7, 1936, *R. Biggs* 10520, det. H. S. Jackson, ex herb. U. Toronto; U. S., California, Humboldt County, Little River Sand Dunes, January 2, 1940, *H. E. Parks* 4, det. G. W. Martin, ex herb. U. Cal. 640701; Austria, Wiener-Wald, August 18, 1907, *Fr. von Hoehnel*, ex herb. von Hoehn., ex herb. Farlow.

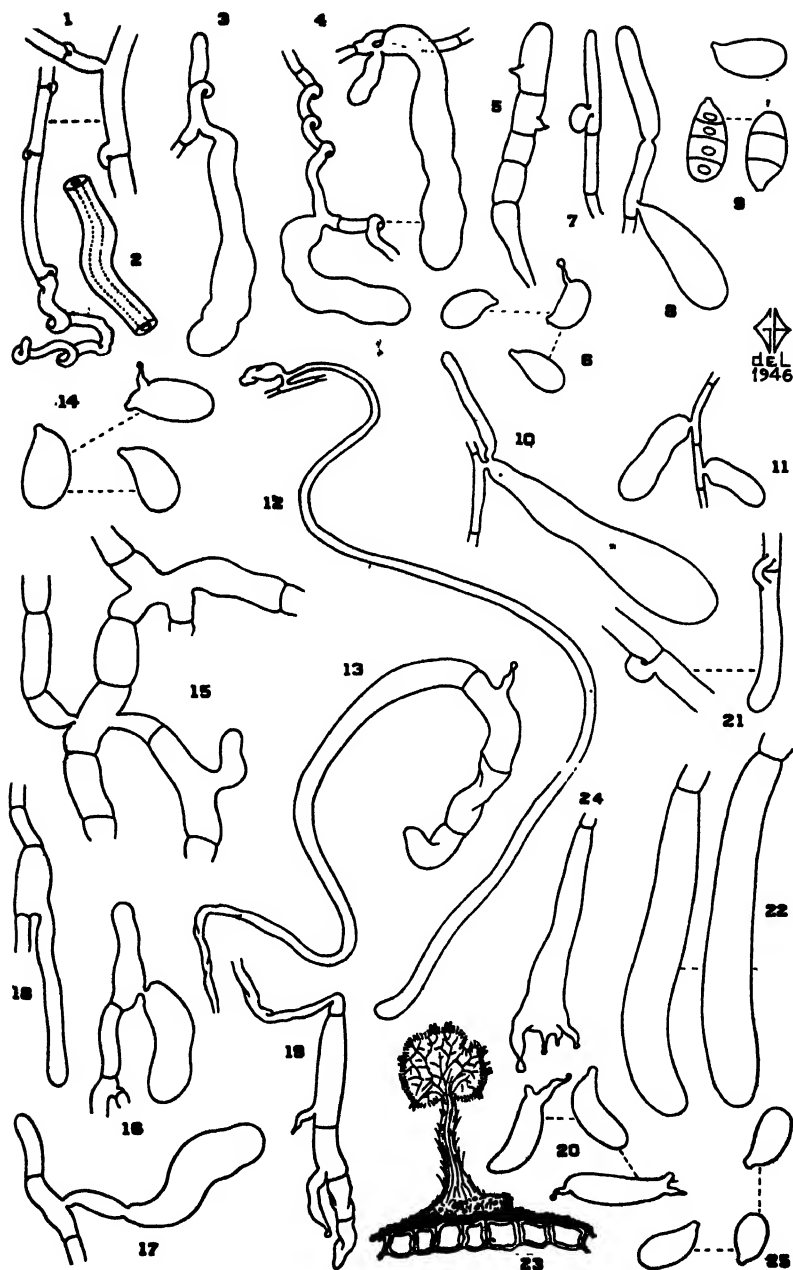
**HELICOGLOEA PINICOLA** (Bourd. and Galz.) Baker, Ann. Mo. Bot. Gard. 23: 89. 1936.

Several gatherings from Canada have been studied which extend the geographical and host ranges of this floccose species. The collections are all on angiosperm substrata. Although this is not the first notation of departure from the described gymnosperm substratum that was the basis of the specific name, the collections do extend the host range considerably, further relegating the specific name to historical interest only. None of the collections is in any way atypical.

**HABITAT:** on decaying wood of alder, hawthorn, hazel, pine, poplar, and willow; humus.

**DISTRIBUTION:** Canada: Manitoba; Ontario; France: Causse Noire, Toulon; Austria: Tirol.

**SPECIMENS EXAMINED:** Canada: Ontario, T. F. R., Lake Timagami, Bear Island, August 30-31, 1936, *H. S. Jackson* and *R. Biggs*, in herb. U. Toronto 9507, ver. G. W. Martin, on *Salix*; *R. Biggs*, August 31, 1936, in herb. U. Toronto 9508, det. H. S. Jackson, ver. G. W. Martin, on *Corylus rostrata*; *H. S. Jackson*, August 12, 1937, in herb. U. Toronto 12403, on *Amelanchier* sp.; woods east of Snell Grove, *A. J. Skolko*, May 21, 1937, in herb. U. Toronto 12404, det. H. S. Jackson, on deciduous wood;



*Helicogloea and Physalacria*



woods west of Maple, *H. S. Jackson*, November 6, 1938, in herb. U. Toronto 13546, on *Alnus*.

***Helicogloea contorta* sp. nov. FIGS. 1-6.**

Fructificatione conspicua, 1 mm. crassa, floccosa, albida; hyphis 2-5  $\mu$  diam., conspicue nodoso-septatis, saepe helicoideis, muris crassis; basidiis intercalariis, saepe helicoideis; hypobasidiis non regularibus, 48-65  $\times$  8-10  $\mu$ ; epibasidiis ex hypobasidiis vel basidiis, 40-45  $\times$  7-8  $\mu$ ; sporis ovoideis, 12-15  $\times$  7.5-9  $\mu$ .

Fructification conspicuous, up to 1 mm. thick, floccose, spreading over an area of several mm., cream-white when dry; assimilative hyphae 2-5  $\mu$  diam., with conspicuous and frequent clamp-connections, often spirally coiled, especially the free surface branches, sometimes with very thick walls; basidial primordia usually intercalary, rarely apical; primordial cell often distinctly coiled, of variable length, giving rise to the hypobasidium 48-65  $\times$  8-10  $\mu$ , irregular, sometimes constricted but not forked; epibasidium commonly arising from the apex of the sac, but occasionally from the primordium; fertile portion 40-45  $\times$  7-8  $\mu$  becoming 3- or 4-celled, each segment producing a single spore; spores ovoid, 12-15  $\times$  7.5-9  $\mu$ , germinating by repetition with one or two germ tubes.

HABITAT: *Quercus macrocarpa*.

DISTRIBUTION: U. S.: Iowa, West Okoboji.

SPECIMEN EXAMINED: U. S.: Iowa, West Okoboji, July 19, 1932, *D. P. Rogers* 829, ex herb. Rogers.

This species differs from *H. pinicola* chiefly in the striking coiling of its hyphae, apical germination of the basidial primordium to the epibasidium, and the smaller size of both the epibasidium and spores.

***Helicogloea longispora* sp. nov. FIGS. 15-20.**

Fructificatione mucedinoidea, grisea; hyphis enodosis, contortis, 2-10  $\mu$  diam., interdum crasse tunicatis; basidiis intercalariis vel apicalibus; hypobasidiis saepe constrictis, 45-50  $\times$  9-11  $\mu$ , interdum defectis; epibasidiis 65-70  $\times$  5-8  $\mu$ ; sporis subcylindrico-fusiformibus, apiculos versus curvulis, 13-15  $\times$  4.5-7.5  $\mu$ .

Fructification mucous-gelatinous, dull gray, inconspicuous when dry; hyphae without clamp connections, irregular, short-celled, sometimes constricted at the septa, 2-10  $\mu$  in diam. with walls of varying thickness; basidial primordia intercalary or apical; hypobasidial sac smooth, or more often once or twice constricted, 45-50  $\times$  9-11  $\mu$ , sometimes missing and then replaced by the swelling of the intercalary primordium; usually germinating from the primordial portion; epibasidium 65-70  $\times$  5-8  $\mu$  or more, producing

spores at ends of long filaments,  $2.5-3\ \mu$  diam., spores subcylindric to fusiform, somewhat tapered at both ends and strongly curved toward the apiculus at the base, with very stout, cylindric apiculus,  $13-15 \times 4.5-7.5\ \mu$ , germinating by repetition with one or two germ tubes.

**HABITAT:** *Pseudotsuga taxifolia*.

**DISTRIBUTION:** U. S.: Oregon, Comstock; Lane County, Lorane.

**SPECIMENS EXAMINED:** Oregon, Comstock, December 11, 1937, A. M. and D. P. Rogers 478, ex herb. Rogers; Lane County, Lorane, el. 400-500 ft., Doty 522, ex herb. Rogers.

Several of the characters of this new *Helicogloea* are striking, namely the short-celled, contorted hyphae; the absence of hypobasidial sac at times; and the elongated, fusiform spores.

**Helicogloea aurea** sp. nov. FIGS. 10-14.

Fructificatione in statu vegeto gelatinosa, albida, in statu sicco membranacea, aurata; hyphis  $4-5\ \mu$  diam., enodosis; basidiis intercalariis, saepe catenatis; hypobasidiis flexuosis, non constrictis,  $55-75 \times 12-16\ \mu$ ; epibasidiis ex apicibus hypobasidiorum vel basidiis,  $260-330 \times 8-9\ \mu$ ; sporis elongato-ovoideis,  $16-25 \times 8-15\ \mu$ .

Fructification when fresh gelatinous but tow-like, white; when dry membranous, golden-orange; hyphae  $4-5\ \mu$  diam., without clamp connections; basidial primordium intercalary, sometimes catenulate; hypobasidium flexuous but not constricted or forked,  $55-75 \times 12-16\ \mu$ ; epibasidium originating from the apex of the sac or occasionally from the primordial portion, very long,  $260-330 \times 8-9\ \mu$ , the fertile portion four-celled; spores elongate-ovoid,  $16-25 \times 8-15\ \mu$ , germinating by repetition with a single germ tube.

**HABITAT:** on decaying wood.

**DISTRIBUTION:** Panama, Prov. Cherique.

**SPECIMEN EXAMINED:** Panama, Prov. Cherique, Valley of upper Rio Cherique Viejo, 1600-1800 m., July 1, 1935, G. W. Martin 2159, ex herb. G. W. Martin.

The extremely large size of the sac, the length of the epibasidial outgrowth, and the character of the fructification are the most outstanding features of this species.

**Helicogloea inconspicua** sp. nov. FIGS. 7-9.

Fructificatione tenui, sparsa, mucedinoides, membranacea, sordide albida; hyphis  $4-5\ \mu$  diam., enodosis; primordiis basidiorum apicalibus; hypobasidiis  $30-52 \times 8-13\ \mu$ , non constrictis; epibasidiis ex apicibus primordii,  $65-115 \times 5.5-8\ \mu$ ; sporis ovoideis, septatis, guttulatis,  $15.5-18 \times 7-8\ \mu$ .

Fructification very inconspicuous, thin, gelatinous to membranous, pallid to straw-colored; hyphae  $4-5\ \mu$  diam., without clamp connections; basidial primordium apical; hypobasidium  $30-52 \times 8-13\ \mu$ , not constricted; epibasidium originating from the apex of the primordial cell,  $65-115 \times 5.5-8\ \mu$ ; spores ovoid, becoming one- to three-septate, often with conspicuous oil drops in the cells,  $15.5-18 \times 7-8\ \mu$ , germinating by repetition.

HABITAT: on decaying wood.

DISTRIBUTION: Colombia, Dept. Magdalena.

SPECIMEN EXAMINED: Colombia, Sierra Nevada de Santa Marta, Dept. Magdalena, Hacienda Valparaiso, 1200-1400 m., August 19, 1935, G. W. Martin 3533, ex herb. G. W. Martin.

The septate spores of this species serve to separate it from *H. Lagerheimi*, which it otherwise resembles quite closely. Septate spores are unknown in all other species of the genus except *H. intermedia* where rarely they are uniseptate.

#### PHYSALACRIA Pk.

Two additional collections of this genus have been seen, one representing a known species and the other a new species.

#### *Physalacria Luttrellii* sp. nov. FIGS. 21-25.

Non conferta; capitulis globosis vel subglobosis, levibus, albidis vel sordide albidis, non cavis,  $0.5-1.0$  mm. diam.; stipite  $1.0-1.5$  mm. alto; hyphis nonnumquam conspicue nodoso-septatis,  $2-5\ \mu$  diam.; hymenio amphigeno; cystidiis cylindricis, non incrustatis,  $40-50 \times 6-7.5\ \mu$ ; basidiis 4-sporis,  $12-15 \times 7-9\ \mu$ ; basidiosporis ovoideo-ellipsoideis,  $8-11 \times 4-5\ \mu$ .

Basidiocarps scattered, head globose or subglobose, smooth, occasionally with a few folds, white to cream-colored, not hollow,  $0.5-1.0$  mm. in diam.; produced on a central stalk up to  $1.5$  mm. high, arising from a well-developed base; in section the head filled throughout with loose reticulate hyphae; the stalk consisting of parallel, closely packed hyphae except for the basal region which is of prosenparenchyma cells covered on the outer surfaces by dark brown pseudoparenchyma cells; hyphae  $2-5\ \mu$  diam., often with conspicuous clamp connections; hymenium amphigenous; cystidia large, not constricted, smooth, more or less cylindrical, projecting,  $40-50 \times 6-7.5\ \mu$  in diam.; basidia four-spored,  $12-15 \times 7-9\ \mu$ ; spores ovoid-ellipsoidal,  $8-11 \times 4-5\ \mu$ .

HABITAT: on dead stems of *Lespedeza bicolor*.

DISTRIBUTION: U. S.: Georgia, Spalding County.

SPECIMEN EXAMINED: U. S., Experiment, Georgia, Spalding County, October 27, 1943, E. S. Luttrell 5153, type, ex herb. Farlow.

This species possesses definite characteristics which readily distinguish it from known species and justify its autonomy. These are its smooth, globular head filled with reticulate tissue; in addition the somewhat larger basidia, the much larger cystidia, and larger spores will separate it from *P. Langloisii*. Likewise its larger basidia, less elongate in form, the type of cystidia, and spore number as well as size will separate it from *P. aggregata*.

PHYSALACRIA INFLATA (Schw.) Peck.

This species, the type of the genus, has been collected frequently in Canada and the United States, but no records outside this continent have been noted so far. A specimen collected in 1938 by R. P. Viegas at Campinas, São Paulo, Brazil, appears to be a typical representative of the species in every way except that the spores are a little small. Such a difference carries insufficient weight for specific segregation.

HABITAT: on bark.

DISTRIBUTION: North America: Canada, Ontario; U. S., Maryland, Nebraska, New Hampshire, Pennsylvania, Wisconsin; South America: Brazil, São Paulo.

SPECIMEN EXAMINED: Brazil, São Paulo, Campinas, November 21, 1938, R. P. Viegas 2599, ex herb. G. W. Martin.

The writer wishes to express her appreciation to Professor G. W. Martin, the University of Iowa, Professor J. S. Jackson, the University of Toronto, and Dr. D. H. Linder, the Farlow Herbarium, Harvard University, for the privilege of using the materials herein described.

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#### EXPLANATION OF FIGURES

All figures were drawn with the aid of an Abbé camera lucida. The magnifications are given for each. *Helicogloea contorta*: all  $\times 575$ . 1.

Hyphae with coils and clamp connections. 2. Hypha showing thick walls and small lumen. 3. Basidium of apical origin. 4. Basidia of intercalary origin. 5. Epibasidium. 6. Spores. *Helicogloea inconspicua*: all  $\times 575$ . 7. Apical origin of basidium. 8. Hypobasidium and epibasidium. 9. Spores. *Helicogloea aurea*: 10. Intercalary origin of basidium, epibasidium from apex of the sac,  $\times 550$ . 11. Young basidia in catenulate series,  $\times 550$ . 12. Epibasidium,  $\times 290$ . 13. Mature epibasidium,  $\times 550$ . 14. Spores,  $\times 550$ . *Helicogloea longispora*: all  $\times 575$ . 15. Hyphae of short segments. 16. Apical origin of basidium. 17. Intercalary origin of basidium. 18. Intercalary origin of epibasidium without development of the hypobasidial sac. 19. Epibasidium. 20. Spores. *Physalacria Luttrellii*: 21. Hyphae with clamp connections,  $\times 575$ . 22. Cystidia showing level of hymenial surface,  $\times 575$ . 23. Diagram of basidiocarp in longitudinal section,  $\times 20$ . 24. Basidium,  $\times 575$ . 25. Spores,  $\times 575$ .

# SPECIES OF ASCOBOLUS FOR GENETIC STUDY

BERNARD O. DODGE AND FRED J. SEAVER

(WITH 1 FIGURE)

War conditions have focused our attention on certain mycological problems which had heretofore received little attention. For example, the destruction of the insulation used in electric equipment in the tropics has created very serious problems. The injury to lenses used in various instruments and the decay of fabrics and wood used in service equipment have also received a great deal of attention. Apparently species of undescribed fungi are often involved. The following is an illustration.

In April, 1945, Dr. George W. Martin while working with the Army Air Forces encountered a species of *Ascobolus* which developed on Japanese fabric from New Guinea. Since it seemed to differ from any of those species recorded from other parts of the world, it was referred to the junior author for study. The first specimen on fabric had been treated with a preservative and the spores were not viable. A culture was then received which was said to have been obtained from a Japanese sock. The following notes on the occurrence of the fungus were received from Dr. Martin.

"The *Ascobolus* which you have been studying appeared on a Japanese sock from New Guinea. This was one of a number of samples of captured enemy material sent in for examination, including test for cellulose-rotting organism. All samples were carefully sealed in glassine envelopes in the field and were opened in the laboratory using aseptic precautions. The surface of the envelope and the glass table in which the operations were performed were swabbed with formalin, all scissors, forceps etc. were flamed and the operations were performed in a closed chamber in which a sterilizing lamp was burning when it was not in use.

"The socks themselves had never been worn but were from a case which had been broken open by shell-fire. Isolations were made on

various media and pieces of the fabric were placed in Petri dishes and wet with a nutrient salt solution lacking carbon. It was on such pieces that the *Ascobolus* appeared in nearly pure culture. The piece sent to you was a transfer from such a growth to a piece of heavy duck, sterilized and wet with the same salt solution. The origin of the socks, of course, is unknown."

This fabricolous *Ascobolus* proved to be of special interest from a taxonomic viewpoint. It seems to possess, along with those features characteristic of *Ascobolus*, some characters that would suggest placing it in the genus *Saccobolus*. Since the ascospores very often appear as separate units in the ascus from the time of their delimitation until they are discharged, the species clearly belongs in *Ascobolus*. Even when the eight spores are clumped together in the ascus and are discharged in a tight clump, characters of *Saccobolus*, the spores are easily separated if a drop of water is added and the clump is lightly touched with a needle. When the fungus fruits abundantly in a plate culture so that a spore-print forms on the cover where water of condensation is apt to collect, the ascospores will seldom be found adhering tightly together in clumps of eight (FIG. 1). The eight spores of a true *Saccobolus* are separated only with some difficulty and then they are usually broken or injured. Boudier (1877), as will be noted later on, pointed out that in some respects *Ascobolus pusillus* is much like a *Saccobolus*, but since the spores are free in the ascus it must be an *Ascobolus*.

An account of the culture work carried on with this fungus and a brief consideration of species of the group as suitable for mycogenetic studies follow the formal description of this species as given below.

#### ***Ascobolus saccoboloides* Seaver, sp. nov.**

Apotheciis sparsis vel gregariis vel confluentibus, sessilibus, pallide flavis, vix 1 mm. diam.; hymenio convexo; ascis late clavatis, 8-sporis, stipitatis,  $150 \times 20 \mu$ ; sporis ellipsoideis, violaceo-fuscentibus, subconglutinatis dein dispersis; paraphysibus filiformibus.

Apothecia scattered or gregarious, often confluent, sessile, pale yellowish amber in color, less than 1 mm. in diameter, hymenium convex, dotted over with the protruding asci; asci broad-clavate, reaching a length of  $150 \mu$  and a diameter of  $20 \mu$ , attenuated below



FIG 1. *Ascobolus saccoboloides* Above, an apothecium crushed to show asci and spores. Below, portion of same enlarged.



into a slender stem-like base, 8-spored; spores clinging together in the ascus *Saccobolus*-like, often discharged together, finally separating, at first hyaline becoming purple then brown, ellipsoid, about  $10 \times 16 \mu$ , smooth or very minutely roughened; paraphyses very slender.

On Japanese fabric from New Guinea.

#### CULTURE WORK

The culture of *Ascobolus saccoboloides* sent us by Dr. Martin was developing large numbers of apothecia (ascocarps) when received. When transfers were made to a potato-dextrose agar medium good mycelial growth was obtained but apothecial development was long delayed and often no apothecia were ever developed. On a peptone-yeast medium which Dr. W. J. Robbins has found very satisfactory for certain types of work on antibiotics, growth was vigorous but no ascocarps ever developed on any of the twelve cultures which have been made. The mycelium grew fairly well on a horse-dung-decoction agar medium, but fruiting was very unsatisfactory. On sterilized horse dung growth was slow but numerous ascocarps finally matured. It was found that a malt extract agar medium was much better suited for ascocarp development. When culturing *Ascobolus Winteri*, Dodge (1912, fig. 2, p. 181) found that although that fungus would grow over large colonies of certain contaminating bacteria, bacteria of another type acted to oppose or prevent growth of the *Ascobolus*. It was found that certain colonies of soil bacteria that had become established in some of our plate cultures that had been opened several times for study, served to stimulate the formation of fruit bodies of *A. saccoboloides*. In some cases a half dozen or more apothecia matured on the bacterial growth while no apothecia were present on the agar in the vicinity of the bacterial colony. No work was done to discover the reason for this phenomenon.

The mycelial hyphae are very fine or thin and branching is rather profuse. Growth is slow as compared to that of many species of *Ascobolus*. While chains of swollen cells resembling spores (or perhaps young ascogonia) were sometimes found on fluffy surface growth no true oidia or other sexual propagating bodies were noticed in our cultures. Large numbers of spirally coiled structures

with free tip ends are often present in the primordial growth. Because the ascocarp primordia are very small we have not attempted to make a study of their nature so we do not know whether or not antheridia and ascogonia take part in reproduction. We were especially interested to determine whether the species might be heterothallic because heterocaryosis and hybridization in fungi are topics much in the minds of many who are concerned with a study of nutrition, general physiology and development of new races of fungi, especially as bearing on the questions of antibiotics and genetics.

At first, we had some difficulty in inducing the ascospores to germinate. On horse-dung-decoction agar germination was so long delayed and the growth of germ tubes so slow that the plates became contaminated from being opened frequently in searching for germinated spores. It was therefore decided to try the single hyphal tip method although we realized that this method has its limitations. The fact that all single tip cultures of an Ascomycete fruit does not prove that the fungus is homothallic.

*Single tip cultures.* Since the mycelium seems to prefer to grow largely on the surface it was not difficult to isolate some two dozen single tips and grow them in tubes of malt extract agar. In due time every one of the cultures developed many ascocarps. In earlier years such evidence would have been accepted as proof of homothallism. A high percentage of single-tip cultures from wild type mycelia of *Neurospora tetrasperma* (Dodge, 1928), would produce ascocarps just as though the species were homothallic. When we see that the mycelium is heterocaryotic, the cells usually carrying two kinds of nuclei as to their mating types, we know that the species is not really homothallic; it is heterothallic, or, at least, facultatively heterothallic. To avoid all uncertainty it was therefore necessary to obtain numerous cultures from single ascospores.

*Single-ascospore cultures.* After experimenting with heat-treatment of ascospores and having found this ineffective, we tried several different kinds of media. Occasionally a few spores germinated after several days. The spores are rather small and the germ tubes are very thin and so very difficult to locate without contamination of the plates. We found that excellent germination could be obtained when ascospores were sown on the surface of

an agar medium which Miss Grace Antikajian is using in her work on *Ascobolus magnificus*. This is made up with a dung decoction to which either whole yeast or yeast extract is added. It was a simple matter to sow ascospores on the surface of this Antikajian medium in plates. A high percentage of germination was observed on the third day. Fifteen single spores bearing germ tubes were transferred to tubes of potato-dextrose agar. Two days later when mycelial growth had become well established on the slants, the original bit of agar bearing the germinated spore in each case was picked out and transferred to a tube of malt extract agar. Good growth was made in all thirty cultures. At the end of six weeks there was no evidence that ascocarps were forming in any of the potato-dextrose cultures. Mature ascocarps had developed in all fifteen malt extract cultures by the end of the third week. *Ascobolus saccoboloides* is therefore homothallic. In three cultures mature spores could be seen on the tenth day. These were the cultures in which large blocks of the dung-decoction yeast-extract medium had been transferred with the germinated spore. At first the ascocarps all developed on the malt extract agar in the tube and not on the dung-yeast block of agar. In Petri-dish cultures with the dung-yeast extract medium no ascocarps could be found at the end of three weeks, but in transfers from such plates to tubes of malt-extract agar ascocarps were forming by the fifth day. From this it is clear that although the yeast extract certainly stimulates spore germination and vegetative growth, it is not favorable for ascocarp development in this case. There was great variation in the times required for the appearance of the mature spores. The first ones were found in a few ten-day-old cultures, but in other cultures mature spores could not be found until after three weeks.

We have not made a study of the method of origin of the ascocarps except to learn, as noted above, that the apothecial primordia are very small and that they occur more or less in clusters or groups. That is, a single ascocarp has its origin in several ascogonia which arise from the surface of the medium and are so close together that the mature ascocarps coalesce giving the appearance of a continuous, though bumpy, hymenial layer. Ascus formation is much delayed where there is extensive coalescing of apothecia. Where the ascocarps are well separated one can often see that the hymenium is

marked off in a way that indicates that ascogenous hyphae have arisen from different ascogonia. Green (1931) and Gwynne-Vaughan and Williamson (1933) have shown that several ascogonia are present at the origin of individual ascocarps of *Saccobolus obscurus* and *S. depauperatus*.

The apothecia are at first pale amber. Later in old cultures they become dark amber and are spotted purple by the clumps of mature ascospores. In many species of *Ascobolus*, particularly the kinds that have a broad hymenial layer, the spores are usually discharged more or less simultaneously in small "clouds." When watching such a spore discharge one can observe how the hymenial surface changes quickly from dark purple to a greenish color. The spores of *Ascobolus saccoboloides* are not discharged in such clouds. In fact mature apothecia are usually spotted with spore-bearing asci in which the clumps of spores are retained a long time. (FIG. 1). Crushed mounts can be photographed readily. There is no movement such as is apt to occur in mounts of other species when spores are discharged. In other words the hymenium is rather "sticky."

#### GENERAL CONSIDERATIONS

*All species of Ascobolus not coprophilous.* Many botanists think of species of *Ascobolus* as belonging to that group of fungi which grow on dung of various animals. No one in recent years has monographed the Ascobolaceae so that we have no reliable source of information on just how many good species of *Ascobolus* there are. Rehm (1896) recognized twenty-two species, excluding varieties, as occurring in central Europe. Of these thirteen were recorded as coprophilous and nine as non-coprophilous. Seaver (1928-1941) in his North American Cup-fungi recognized sixteen species of *Ascobolus*, of which nine are coprophilous and seven non-coprophilous. *A. saccoboloides* is a good example of a species which grows well on fabric. We should add two more species to Seaver's list of the non-coprophilous species. *A. pusillus* Boud. was collected on old burned ground during three different summers at White Post, Virginia. Although its habitat and spore markings are much the same as those of *A. carbonarius* it is a distinct species (see Dodge, 1921, pl. 10, fig. 8). He studied spore

germination and found that "heat treatment" which had proved so effective in inducing germination of spores of *A. carbonarius* was not effective with spores of *A. pusillus*. A good slide mount of this species will be found in the herbarium of the New York Botanical Garden. This mount shows great variation in size and aspect of the spores as was noted by Boudier in *Icones Mycologiceae* (pl. 412 f. a-i). That author (1877) pointed out that the paraphyses are much like those of a *Saccobolus* and it is otherwise ~~also much like~~ a *Saccobolus* except that the spores are free in the ascus. *A. saccoboloides* is even more like a *Saccobolus*. Yet the presence of free spores in asci relates it more to *Ascobolus*.

*A. viridis* Curr. var.? as reported and figured by Dodge (1912) was very commonly found on black muck soil under alder (*Alnus*) bushes at "Springside" near Hackensack, New Jersey. It is a rather large pale greenish species. Its ascospores are the same shape as those of *A. viridis* Curr. but they are smaller. The spore markings are much the same. Ascospores of *A. geophilus* are elliptical with well-rounded ends whereas those of the American *A. viridis* are rather pointed (see Seaver, 1928, pl. 7, fig. 2 and Dodge, 1912, pl. 10, fig. 2-4). Dodge reported that he had difficulty in germinating spores of his *A. viridis* and heat-treatment also was not effective. Betts and Meyer (1938-1939) found that ascospores of *A. geophilus* Seaver germinate readily without any special treatment whatsoever. This fact alone would serve to distinguish *A. viridis* var. from *A. geophilus* with which, because of its habitat, it might be confused. Counting then *A. pusillus* and *A. viridis* Curr. var.? Seaver would have nine coprophilous and nine non-coprophilous species of *Ascobolus* for America. Grelet (1944) reports twenty-one species of *Ascobolus* in France. Of these only eleven were coprophilous.

*Heterothallism in Ascobolus.* Following the report (Dodge, 1920) that *Ascobolus magnificus* is heterothallic, Betts (1926) proved that *A. carbonarius* is also heterothallic. The latter species (see also Betts and Meyer, 1941) would certainly furnish excellent material for genetic studies. As a rule all eight spores from an ascus will germinate following heat-treatment. It has numerous distinct morphological characters which would serve well for genetic work.

Ames (1930) recorded *A. stercorarius* as "hetero-homothallic." "Single spore cultures of this species gave rise to a few apothecia." He found, however, that by mating certain single spore mycelia in culture he could obtain a much larger number of apothecia.

Green (1931) reported on her culture work with *A. stercorarius*, *A. glaber*, *Dasybolus* (*Ascobolus*) *immersus* and *Saccobolus obscurus*. Certain cultures of *A. stercorarius* obtained from single ascospores finally, after several months, produced ascocarps. This would ordinarily suggest that the species is homothallic. She found, however, that other single-spore cultures remained sterile. These strains, she proved, were of two kinds such that members of her group A fruited rather quickly with any member of her group B. This behavior suggested that the species might be heterothallic and not homothallic. Dowding (1931) proved that *A. stercorarius* is in fact strictly heterothallic. She showed how any fruiting of what were supposed to have been single-spore mycelia, such as reported by others previously, was probably due to the transfer of oidia of one sex to a mycelium of the opposite sex by mites or other means of contamination.

Betts and Meyer (1938, 1939) proved by careful culture studies that *A. geophilus* Seaver is heterothallic.

Although both Ames (1930) and Green (1931) found that the few single-spore cultures of *A. immersus* which they were able to obtain did not produce apothecia, Rizet (1939) was the first to report culture experiments which actually proved that the species is heterothallic. Rizet says that he obtained a number of cultures derived from single ascospores and in each case ascogonia were formed but no ascocarps with spores ever developed. A number of these cultures produced microconidia. By mating these self-sterile unisexual strains in various combinations he proved conclusively that *A. immersus* is heterothallic. One of his matings, No. 4—No. 15, was especially interesting because the  $F_1$  asci matured spores of two kinds as to their color, four being normal and purple, the other four were colorless and sometimes smaller. Rizet proved that this segregation four and four for color was not an indication of sex or of mating type because in some asci the colored spores were of one sex while in others the colored spores were the opposite sex. When he mated two races derived from colored spores, all

eight spores in the  $F_1$  asci were colored. In matings of races derived from colorless spores the  $F_1$  asci all had eight colorless spores. Rizet had not seen Zickler's (1934) paper in which that author had earlier found a similar segregation in asci of *Bombardia lunata*.

Rizet has reported another case where he had mated race No. 25, derived from a colorless spore, with race No. 34, derived from a colored spore. The spores in the  $F_1$  asci were all colorless. He attributed this unilateral segregation to the effect of hormone action such as had been reported by Moreau and Moruzi for *Neurospora*. Rizet did not carry out this highly interesting experiment to its logical conclusion. He did not say whether or not the eight spores in such asci were all of the same sex. Until better proof is forthcoming we may be pardoned for not being wholly convinced on this point. Where a species like *A. immersus* produces many microspores one should be on the watch for contaminations by these minute spores. If he used the heat-treatment method to induce ascospore germination the microconidia carried over accidentally would be killed, but this would not prevent cross fertilization by microconidia later on. Moreau and Moruzi, Lindegren and Rizet all seem to believe that diffusible hormones are responsible for this unilateral fruiting, but little evidence has been furnished to prove this to be a fact, plausible as Lindegren's (1934) explanation might at first seem to be. It ought to be comparatively easy to filter out these hypothetical "hormones" from broth cultures and apply them to the "self sterile" mycelia and make them fruit. *Ascobolus immersus* is world wide in its distribution and it can be found on dung in almost any pasture during the summer. It should be, as Rizet says, an excellent species with which to work genetically.

We have, therefore, in America at least five heterothallic species of *Ascobolus*, namely *A. magnificus*, *A. carbonarius*, *A. stercorarius*, *A. geophilus*, and *A. immersus*. Excepting perhaps the first named, *A. magnificus*, a high percentage of the ascospores can be induced to germinate. Spores of *A. geophilus* grow readily without any special treatment whatever. Spores of *A. carbonarius* and *A. immersus* respond very satisfactorily to heat-treatment but those of *A. stercorarius* respond less satisfactorily. All five species have good morphological characters and are widely distributed in this

country. Certain principles of inheritance are much more clearly expressed by these haploid organisms than they are in diploid plants and animals. For this reason as is abundantly evident from the work of Lindegren, Beadle, and others, such haploid organisms as species of the Ascombolaceae should be thoroughly investigated genetically if found to be heterothallic.

*Homothallic species.* Although the ascospores of *Ascobolus Winteri* readily germinate when given the heat-treatment (Dodge, 1912) he made no statement as to single spore cultures producing ascocarps. He has always assumed, however, that *A. Winteri* is homothallic. This point should be cleared up by adequate culture studies with single ascospores. This species has been very commonly found on goose dung<sup>1</sup>.

Schweizer (1923) described the development of a new species, *Ascobolus citrinus*. No antheridia were discovered. His report on his culture work does not indicate whether or not the species is homothallic. Later (1931) he does prove that *A. strobilinus* is homothallic. Whether or not *A. glaber* and *Saccobolus obscurus* are homothallic, Green (1931) does not say definitely.

Gwynne-Vaughan and Williamson (1933) state that they grew in culture a number of species of the Ascombolaceae and made some preliminary observations on their development. "As it happened," they say, "all proved to be homothallic." Among those studied were *Ascobolus viridulus*, *A. Leveillei*, *A. equinus*, and *Saccobolus depauperatus*. It is not clear whether they intended to include in the list of homothallic species *A. stercorarius* (*A. furfuraceus*) and *A. immersus*. Probably they did not for as noted above they are both strictly heterothallic.

The ascocarp of the following species has been proved to originate normally from a single ascogonium: *A. stercorarius*, *A. immersus*, *A. citrinus*, *A. Winteri*, *A. viridulus*, *A. equinus*, *A. Leveillei*; from a single pair of sex organs: *A. magnificus*, *A. carbonarius*.

The ascocarp of the following species has been reported to arise from a number of pairs of ascogonia and antheridia: *A. strobilinus*, *Ascophanus aurora*, *Ascodesmis microscopica* (*nigricans*). Ascocarps of *Saccobolus depauperatus*, *S. obscurus* and *Ascobolus saccoboloides* are known to have several ascogonia at their origin but no one has reported that antheridia are also present.



Those who still hold that there occur two successive nuclear fusions followed by a double reduction in the life history of an individual Discomycete could very easily settle this question by a genetic study of species *Ascobolus*. With only a single nuclear fusion and that one in the ascus, there can normally not be more than four genotypically different kinds of ascospores in an ascus. If the spores are disposed or arranged in a definite line in the ascus, they will be found to alternate four and four, two and two, or two four two for any pair of genetic factors. With a double fertilization and double reduction one should find many asci with eight different kinds of spores, and if the spores are in linear arrangement they should very frequently alternate one and one for members of a pair of factors, such, for example, as mating type factors. Betts and Meyer (1939, 1941) state that the spores in asci of *Ascobolus geophilus* and *A. carbonarius* were arranged four and four or two and two for the sex factors in the asci they analyzed. The number of asci analyzed was perhaps not large enough to be fully convincing to those who hold to the double fertilization theory. If we add *A. immersus* we would have three species readily available and well adapted for genetic studies. Of course best of all would be *A. magnificus* and *A. stercorarius* if one could find a better way of inducing a high percentage of spore germination. The former species has an interesting *Papulaspora* asexual stage while the latter produces many microconidia when properly grown.

THE NEW YORK BOTANICAL GARDEN

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# POLYPORUS GUTTULATUS AND PTYCHOGASTER RUBESCENS<sup>1</sup>

ROSS W. DAVIDSON, CLYDE M. CHRISTENSEN, AND ELLIS F. DARLEY \*

(WITH 3 FIGURES)

## DISTRIBUTION OF POLYPORUS GUTTULATUS

Peck (14, 15) described *Polyporus guttulatus* Pk. (*P. maculatus* Pk.) from sporophores collected in New York about 1872. Lloyd (5) considered Peck's fungus to be the same as *P. alutaceus* Fr. of Europe, stating, "This species grows on pine and is rather rare both in Europe and the United States." He recorded a specimen from New York (6) and one from Michigan (7). Overholts (10) considered it rare on wood of coniferous trees in Ohio and later (11) listed it from Michigan and Wisconsin. He stated (12) that it is frequent on dead wood of coniferous trees. Lowe (8) also considered it "frequent" on wood of coniferous trees and doubtful on beech. Newman (9) recorded it as common in northern Wisconsin on pine and hemlock stumps and logs. Shope (17) did not include it among his Colorado polypores, but it was collected in the Great Smoky Mountains in Tennessee by Kauffman (4) although the kind of wood on which it was growing was not stated. Overholts collected it on fallen *Abies balsamea* (L.) Miller in New Hampshire (13), and Zeller (19) reported it on oak from Oregon. The following specimens of *P. guttulatus* and *P. alutaceus* Fr. are in the mycological collections of the Bureau of Plant Industry, all of them collected from dead wood.

<sup>1</sup> Cooperative paper of the Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, Beltsville, Maryland, and Division of Plant Pathology and Botany, University of Minnesota, St. Paul, Minnesota. Paper No. 2287 of the Scientific Journal Series, Minnesota Agricultural Experiment Station.

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*Pinus* sp. Star Lake, Wis., 1904, coll. R. A. Harper; 190; Hunt Co., Pa., July, 1936, W. A. Campbell & L. O. Overholts (F.P. 71143); Neebish Island, Mich., Aug., 1899, E. T. Harper (F.P. 20702).

*Pinus contorta* Dougl. ex. Loud. Bonner Co., Idaho, Aug., 1920, J. R. Weir, 15110 and 15352.

*Pinus monticola* Dougl. ex D. Don. Priest River, Idaho, 1912 and May, 1915, J. R. Weir, 1285; in Canada near Metaline Falls, Wash., J. R. Weir, 2123; another collected in Idaho in 1926, J. H. Rust, 1121.

*Pinus ponderosa* Lawson. Crater Lake, Oregon, Sept., 1916, J. R. Weir, 8697.

*Larix occidentalis* Nuttall. Coolin, Idaho, Sept., 1910, G. G. Hedgcock (F.P. 4708); Halfway House, Idaho, Aug., 1911, G. G. Hedgcock & J. R. Weir (F.P. 11009); Coolin, Idaho, Sept., 1919, coll. J. R. Weir, 11327.

*Picea glauca* (Mill.) B.S.P. Lake Timagami, Ontario, Sept., 1918, J. H. Faull, 3186; Hayward, Wis., Oct., 1919, C. J. Humphrey, 9897.

*Picea mariana* (Mill.) B.S.P. Carry Pond, Me., Aug., 1920, P. Spaulding (F.P. 38115).

*Tsuga heterophylla* (Raf.) Sargent. Bonner Co., Idaho, Aug. 12, 1920, A. S. Rhoads (J. R. Weir 15235), also in U. Idaho Forest Path. Herb. 3517; Leu Boehls, Idaho, Aug., 1923, C. R. Stillinger, 944.

*Pseudotsuga taxifolia* (Poir.) Britton. Douglas, Ariz., Sept., 1908, H. D. Burrall (F.P. 1141); Olympia, Wash., Oct., 1909, C. J. Humphrey (F.P. 6011 and 6012); Stonewood, Wash., Sept., 1910, C. J. Humphrey (F.P. 6301 and 6302); Bellingham, Wash., Sept., 1916, J. R. Weir, 8017; Detroit, Oregon, Oct., 1909, G. G. Hedgcock (F.P. 1754).

*Abies balsamea* (L.) Miller. Hebron, N. H., Aug., 1905, Percy Wilson.

*Abies grandis* (Dougl.) Lind. Bark Camp, Idaho, July, 1925, J. R. Stillinger.

*Thuja plicata* D. Don. Priest River, Idaho, 1915, J. R. Weir, 4733. (Also in U. Idaho For. Path. Herb. 3520.)

No host was mentioned for other specimens, including several from New York and several from Wisconsin. All of the Forest Pathology (F. P.) specimens were identified or verified by L. O. Overholts and most of the others were identified by J. R. Weir, A. S. Rhoads, C. G. Lloyd, and W. A. Murrill. The C. G. Lloyd Herbarium has a number of specimens under the name *Polyporus alutaceus* but hosts are not listed for any of them.

J. R. Hansbrough supplied data on thirteen sporophore specimens in the New Haven, Conn., Forest Pathology branch office herbarium. Most of them were collected in the New England States. The hosts with number of collections from each are as follows: *Acer rubrum* 1, *Abies balsamea* 4, *Picea mariana* 1, *Picea rubens* 6, *Tsuga canadensis* 1. G. H. Englerth sent information on four specimens in the Madison, Wis., Forest Pathology Herbarium, all

of which were collected by Hubert in Minnesota. Three were on windfall trees.

These specimens and literature references show that *Polyporus guttulatus* is distributed throughout the northern tier of States and in Canada where its host trees occur, and may extend southward into the Great Smoky Mountains.

POLYPORUS GUTTULATUS FROM BUTT ROT OF CONIFERS IN  
MINNESOTA

From 1935 to 1939 Christensen found *Polyporus guttulatus* fruiting on six trees or stumps in and near Itasca Park, Minnesota. Overmature and wind-thrown trees of coniferous species native to the area are rather abundant there. The fact that the fungus was found on only six different individuals during the five years, even though it was sought from late July to early September each year, suggests that in the area observed sporophores of the fungus are relatively rare. Three of the six trees on which the fungus was found were black spruce (*Picea mariana*), two were balsam fir (*Abies balsamea*), and one was Jack pine (*Pinus banksiana* Lamb).

Approximately thirty fruit bodies were found on the stump of a recently wind-thrown black spruce, Aug. 23, 1938 (FIG. 1). Only a thin shell of sound wood remained in the lower trunk and in the roots as far as six feet from the base of the tree. Visible decay extended up the trunk about ten feet from the ground, and cultures of *Polyporus guttulatus* were obtained two feet beyond this, but not five feet beyond. The decayed wood when first exposed was pale brown and of uniform, cheesy texture, but later darkened and broke up into cubical fragments typical of the decay caused by *P. guttulatus*.

Twelve to fifteen fruit bodies were found near the same place on a living black spruce. Only one or two fruit bodies were found on each of the other four trees or stumps on which the fungus was collected. Cultures made from both the fruit bodies and the decayed wood served as a basis for the cultural descriptions given below.

The characters of the fruit bodies as determined from more than fifty fresh specimens collected in and near Itasca Park over a period of five years differ in some respects from the available descriptions of *Polyporus guttulatus*, and therefore it seems worth

while to summarize them, as follows: The fruit bodies are usually sessile, 6-15 cm. wide (the majority about 10-12 cm. wide), project from the wood 6-12 cm., are 1.5-4.0 cm. thick at the base, and are attached to the wood by a narrow, lateral, stemlike base. Sometimes the fruit bodies have an almost central stem, with several

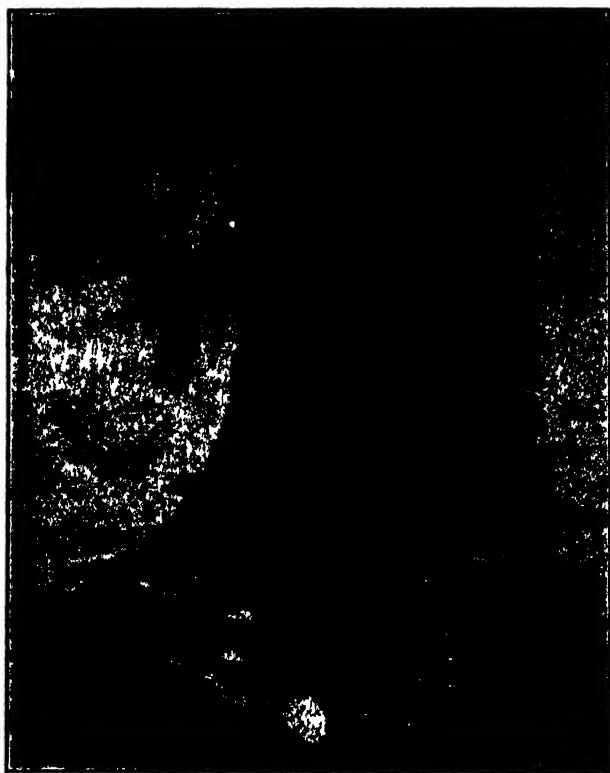


FIG. 1. Fruit bodies of *Polyporus guttulatus* on *Picea mariana*. The tree had broken over because of decay by this fungus.

semicircular or nearly circular shelves coming out at different levels, but this is exceptional and occurs only when the fruit body arises from a root beneath the surface of the ground. The upper surface at first is white or nearly so, usually slightly rough or pitted, and covered with fine, short mycelia. It slopes down from the margin to the point of attachment, thus being shallow funnel-shaped. Usually there are three to five broad, inconspicuous concentric

ridges on the surface, indicating the periods of growth during the formation of the fruit body. Sometimes these ridges are pale reddish-brown. Faint, narrow, radial ridges often are present also. The surface of fruit bodies formed on recently dead or dying trees may become covered with insect frass and debris from the wood-boring and bark beetles that infest these trees, and the fungus often grows over and incorporates this debris in the surface, causing it to be rough. Some old fruit bodies are almost uniformly reddish-brown on top. The context is 1-4 cm. thick at the stemlike base, 2-3 mm. at the margin, white, obviously fibrous, and the fibers extend radially and slant up from the central plane toward the upper surface and downward toward the pores. The context is firm but fairly brittle when fresh, and without obvious growth zones. The pores are 4-9 mm. long at the place of maximum length, and disappear at the margin. They are 40-50 per cm., uniform in diameter throughout the fruit body, oval, circular or irregularly circular in cross section, and the walls are rounded at the open end and about as thick as the diameter of the pores. The pores are pale yellow inside and in fresh specimens become pale reddish-brown when bruised. Sometimes the pores are in two or three rather definite, separable layers, each layer 2-3 mm. long, and probably formed during a separate growth period. When young and growing in a humid atmosphere the fruit bodies exude a clear liquid in drops all over the surface. Fresh fruit bodies have a faint, but definite and rather sweet odor. The microscopic characters of the fruit bodies examined did not differ from those described by Lowe (8) and hence will not be given.

Two roots, each 1-2 inches in diameter on each of twenty black spruce trees (ten of the trees were in an arboretum and were approximately twenty years old, and ten were in a forest near where fruit bodies were found on a wind-thrown tree), were inoculated with *Polyporus guttulatus* in 1938. A hole was bored almost through the root, about two feet from the trunk, with an increment borer, context and pore tissue from fresh fruit bodies were inserted into the hole, and the hole was plugged with a tight peg of black spruce wood. In most cases the peg was tight enough to split the root slightly. On one root of each tree, checks were made by boring a hole and putting in a plug. When last examined, in

1943, five years after inoculation, there was no visible decay in any of the inoculated roots. Although few conclusions can be drawn from such negative evidence, this does at least suggest that *P. guttulatus* does not enter readily through root wounds, although such observational evidence as is available on the decay caused by *P. guttulatus* in living trees uniformly indicates that the decay begins in the roots.

#### PTYCHOGASTER RUBESCENS

*Ptychogaster rubescens* Boud. was described first in Europe (1) and is known only in its conidial stage, which occurs on coniferous wood. Many herbarium specimens of *Ptychogaster* have been examined and some of those identified as *P. albus* Corda by various collectors are very similar to the *P. rubescens* of this report. One of these, in the C. G. Lloyd Herbarium (55333) from Belgium (ex herbarium of E. Bommer and M. Rousseau 10664), is a mass of light purple-brown spores, 2-3 cm. across, intermixed with spruce twigs and needles. Spores are almost smooth, light brown, and 6-9  $\mu$  long, which is about the size of spores produced in cultures observed by the writers. A note with this specimen states, "common on logs and trunks of conifers lying on the ground." Most of the specimens of this type are from Europe, but one in Lloyd's Herbarium (55335) is somewhat similar to 55333 and was sent by D. W. Weiss (57) from Massachusetts. Another Lloyd specimen (55510) was found by R. H. Dennenston on soil at Madison, Wis., in October, 1902. Many of the specimens listed under the name of *Ptychogaster albus* have smaller spores, with walls slightly roughened, and many have hyaline conidia that may be immature or developed under conditions of temperature and moisture that prevented expression of typical characters. However, specimens with consistently smaller, light brown spores, or those with rough-walled spores probably are not at present referable to *P. rubescens*.

Bourdot and Galzin (2) list several European polypores (*Leptoporus albidus* (Schaeff. ex Fr.) Bourd. & Galz., *L. destructor* (Schr.) Bourd. & Galz., and their various forms) with conidia somewhat like those of *Polyporus guttulatus* and *Ptychogaster rubescens*, but without a much more extensive study and comparison of cultures from these European species of *Polyporus* it is impos-



sible to determine whether they are related closely to those herein described.

#### CULTURAL CHARACTERISTICS

Cultures from the fruit bodies of *Polyporus guttulatus* found in Itasca Park were sent to Ross W. Davidson for identification in 1936, 1937, and 1938. In 1939 a fungus isolated from a typical sporophore of *Ptychogaster rubescens* on cypress wood from a greenhouse bench in St. Paul was also sent to Davidson for identification and was found to resemble closely the cultures of *Polyporus*

TABLE 1  
GROWTH AND REACTION OF *Polyporus guttulatus* AND *Ptychogaster rubescens* ON MALT, GALLIC ACID, AND  
TANNIC ACID MEDIA

Fungus	Culture Number	Diameter Growth in Millimeters					
		On Malt Agar		On Gallic Acid*		On Tannic Acid*	
		7 days	14 days	7 days	14 days	7 days	14 days
<i>Polyporus guttulatus</i>	638 (Mounce)	8	50	21	55	0	0
do	71286	8	40	11	42	0	0
do	71799	8	35	16	40	0	0
<i>Ptychogaster rubescens</i>	C.B.S.	44	90+	27	58	tr	tr
do	Minn.	46	85	29	52	0	0
do	970 Idaho	44	90	25	56	0	0

\* All cultures had a 0 reaction on gallic acid and tannic acid media and all belong to the growth and reaction group 3 described by Davidson, Campbell, and Blaisdell (3).

*guttulatus*. In 1941 a similar culture was obtained from Baarn, Holland, under the name of *Ptychogaster rubescens* Boud. (18). An additional culture of a conidial fungus was isolated from brown rot in cedar poles at Moscow, Idaho, by Ehrlich. The fact that these several isolates were obtained from wood products suggested that a more thorough study was necessary to determine the relationships of the isolates from various sources.

Cultures of *Polyporus guttulatus* are consistently slower growing (Table 1 and fig. 2) than the cultures of *Ptychogaster rubescens* from Holland, from the greenhouse bench in St. Paul, and from a

cedar pole in Idaho. They do not develop so large and coarse a mass of mycelium and spores. Cultures from both fungi are white at first and after about a week become colored by the mass of conidia that develop on the mycelia (FIG. 2). *P. guttulatus* also has a slightly lower temperature optimum (Table 2). These differences are well illustrated by Tables 1 and 2 and Figures 2 and 3.

*Ptychogaster rubescens* develops more color, probably because of the greater mass of mycelium and spores. On two per cent malt agar in diffused light cultures become "vinaceous-buff"<sup>2</sup> or "salmon-buff" to "cinnamon-drab." Old test tube cultures are "cream

TABLE 2  
DIAMETER GROWTH OF *Polyporus guttulatus* AND *Ptychogaster rubescens* AT FIVE DIFFERENT CONSTANT TEMPERATURES IN THE DARK

Fungus	Culture Number	14° C.		22° C.		26° C.		32° C.		35° C.	
		7 days	14 days	7 days	14 days	7 days	14 days	7 days	14 days	7 days	14 days
<i>Polyporus guttulatus</i>	(Mounce)										
	638	18	50	33	82	17	71	0	0	0	0
do	7286	14	34*	29	66	20	50	0	0	0	0
do	71799	13	33*	24	65	21	49	0	0	0	0
<i>Ptychogaster rubescens</i>	C.B.S.	17	49	33	90*	40	90*	13	22	0	0
do	Minn.	16	45	38	87*	43	90*	24	39	0	0
do	970										
	Idaho	14	44	35	89*	44	90*	16	38	0	0

\* Trace of pink appeared in the white mycelium.

buff" to "cinnamon-buff." Cultures of *Polyporus guttulatus* do not color up so quickly, and the color is more variable, apparently being more sensitive to room temperatures than those of *Ptychogaster rubescens*. Cultures of *P. guttulatus* one to two weeks old in diffused light are white to "ivory-yellow" to "cream-buff" and old test tube cultures are "light vinaceous-fawn" to "fawn-color." The colors of both fungi are slightly darker when grown on malt agar containing 0.5 per cent gallic acid, and both fungi give a negative oxidase reaction that indicates that they cause a brown, carbonizing rot. Cultures of both have abundant clamp connections.

Conidia formed by *Ptychogaster rubescens* are hyaline to light

<sup>2</sup> Colors in quotes according to Ridgway (16).

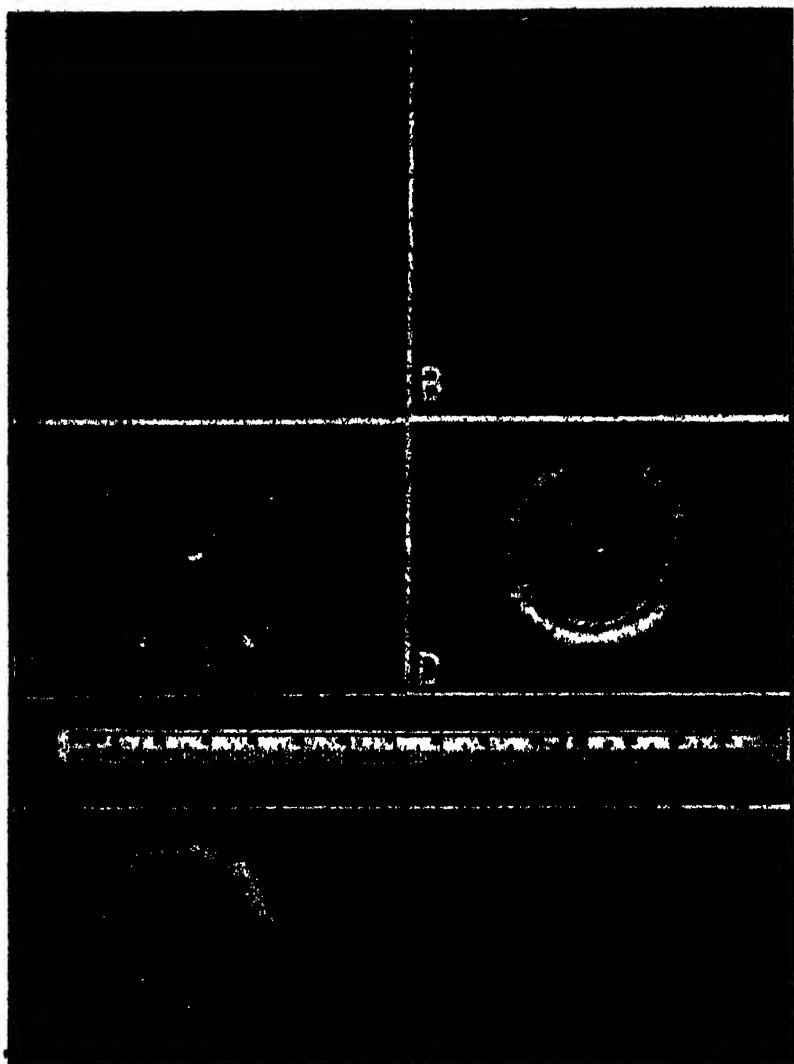


FIG. 2. *Polyporus guttulatus* Pk. and *Ptychogaster rubescens* Boud. grown at room temperature of about 26° C. A and B. *P. rubescens* (Idaho and Minnesota culture), after three weeks on two per cent malt agar. C and D. *P. guttulatus* (71286-R and 71799-S), grown under same conditions as A and B. E and F. *P. rubescens* (Holland culture), after fourteen days on two per cent malt agar containing 0.5 per cent gallic and tannic acid respectively.

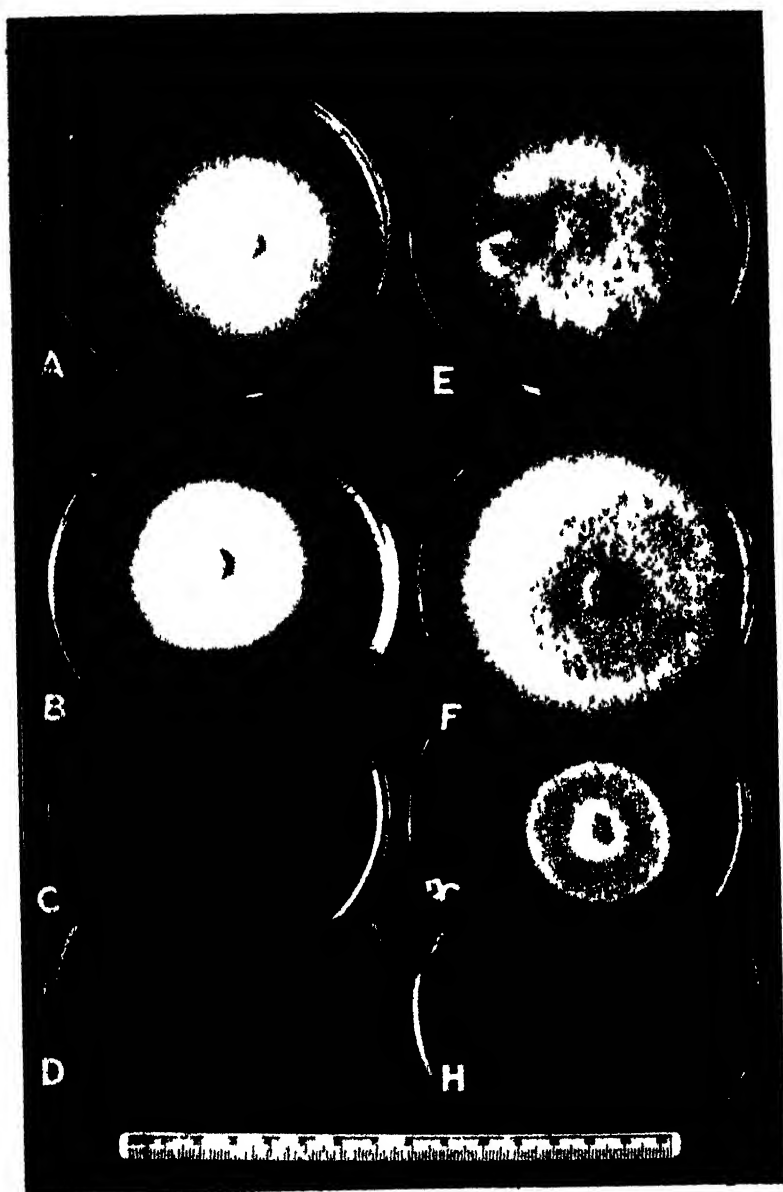


FIG. 3. A to D *Polyporus guttulatus* Pk (71799-S) and E to H, *Pychoqaster rubescens* Boud (Idaho culture) A and E, Cultures grown on two per cent malt agar, in the dark, at a constant temperature of 22° C; B and F, at 26° C.; C and G, at 32° C; and D and H, at 35° C.

brown, elongate, rounded at one end and often truncate at the other, and measure  $6-9 \times 3-4 \mu$ , whereas those of *P. guttulatus* are similar except that they are usually lighter brown and  $5-7 \times 2.5-4 \mu$ .

Both fungi when grown on sterilized blocks of moist coniferous wood cause a brown cubical rot within a few months. Cultures of *Polyporus guttulatus* often form abortive sporophores on such wood blocks, and sometimes on malt agar in test tubes. These sporophores are hemispherical, 3-6 mm. in diameter, pale tan with a greenish tinge, and consist of a mass of daedaloid pores in which typical basidia and basidiospores are borne.

Cultures of *Ptychogaster rubescens*, obtained from the conidial fruit body on cypress wood of a greenhouse bench in St. Paul, were inoculated into bolts of cypress (*Taxodium distichum* (L.) Richard) about 8 inches in diameter and 30 inches long in October 1942. In 1944 several fruit bodies appeared—first the hemispherical masses of brown conidia, then white shelves of polypores; the latter were tentatively identified as *Polyporus guttulatus* by Davidson and Overholts. Cultures made from these shelflike fruit bodies were identical with the original cultures of *Ptychogaster rubescens*. This evidence, supported by that obtained from the comparison of cultures, suggests that *Ptychogaster rubescens* may be no more than a variety within the limits of variation of *P. guttulatus*.

#### SUMMARY AND CONCLUSIONS

Fruiting bodies of *Polyporus guttulatus* were found associated with a brown butt rot of living black spruce (*Picea mariana*) as well as with a brown butt rot of dead black spruce and other coniferous species or on stumps of conifers in Minnesota. It is believed that in most cases the fungus enters through roots of living trees and causes heart rot in the lower part of trunks of such trees while they are still alive. The sporophores usually develop after the trees die or are felled.

Cultures from the sporophores of *Polyporus guttulatus* from the decayed black spruce resembled cultures of *Ptychogaster rubescens* from a greenhouse bench, a cedar pole, and one from an unknown source in Holland. Cultures of *Ptychogaster rubescens* grew faster and had a slightly different temperature range than those of *P. guttulatus*.

A cypress log inoculated with a pure culture of *Ptychogaster rubescens* developed a *Polyporus* sporophore tentatively identified as *Polyporus guttulatus*. At present the writers suggest that *P. rubescens* may be only a variety of *P. guttulatus*.

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## MYCOLOGICAL NOTES. VIII

C. L. SHEAR

(WITH 1 FIGURE)

### 32. SPHAERIA ALBOPRUINOSA Schw.

No specimen of this species is to be found in the original packet so labelled in Schweinitz' herbarium. The label says "Hope," which was apparently the New Jersey locality cited by Schweinitz (Syn. Fung. Am. Bor. 195, no. 1238. 1832). Hope is a small town northeast of Phillipsburg.

There is an autographed Schweinitz' specimen at the Philadelphia Academy of Natural Sciences in the Collins' series of Sphaerias collected by Schweinitz. The host is evidently *Salix* and not *Fagus* as given in the original description. A slide from this specimen shows allantoid, yellowish spores,  $12 \times 4 \mu$ . Schweinitz' specimen in his mounted collection at the Academy appears the same under a lens and is on the same host, but is young or poorly developed and spores could not be found. M. C. Cooke, who transferred the species to *Diatrype* (Grev. 13: 37. 1884) notes, "Sporidia allantoid, pale fuscous, .02-.022  $\times$  .004 mm." As no specimen is cited, these measurements may have been supplied by W. C. Stevenson who furnished information on Schweinitz' material to Cooke, as indicated in the introduction to the latter's article (l. c.). There appears to be an error in the length of spores cited since others, the writer included, have found them to measure  $12-16 \times 2.5-4 \mu$  as recorded by Ellis (No. Amer. Pyren. 570. 1892).

*Eutypella sheariana* Berl. (Icones Fung. 3: 68, pl. 83, fig. 1. 1905) is simply a form of *Diatrype albopruinosa* with small stromata as originally determined and labelled by the writer under his no. 576. A portion of this collection was sent to Berlese, who described it as a new species and gave the spores as  $14-16 \times 4-5 \mu$ . By a typographical error the specific name was printed "*sehariana*." Our portion of this collection agrees with Schweinitz' type in every particular, except that some of the stromata are smaller than

usual. Berlese did not see any of Schweinitz' specimens of *S. albopruinosa*, but refers it on the basis of descriptions to *Diatrype disciformis* var. *macrospora* Berl. It is not clear why he referred my specimen to *Eutypella* as it has a typical diatrypoid stroma. I was unable to locate Berlese's types in Italy. There are, however, all

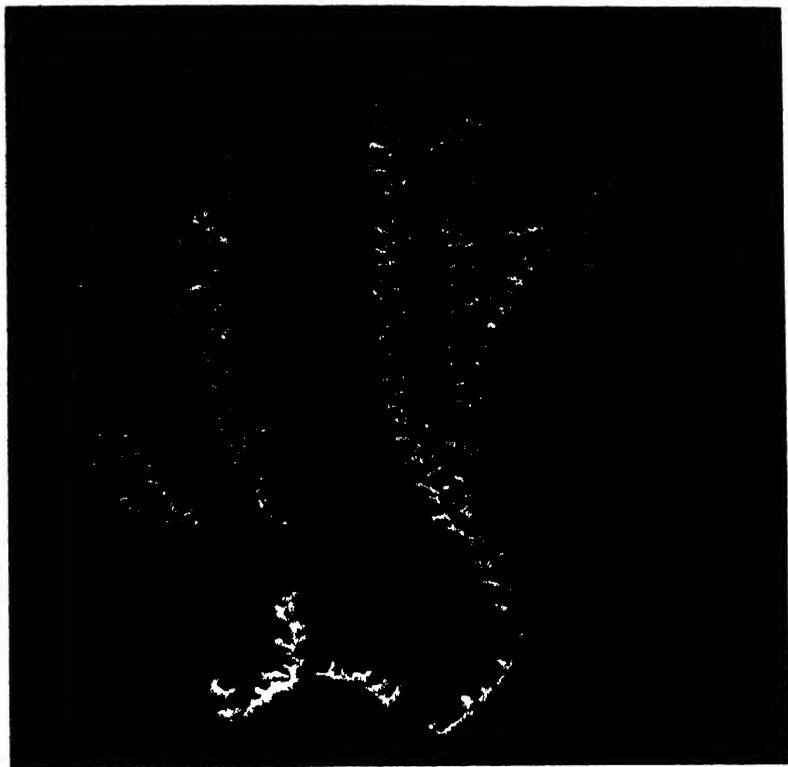


FIG. 1. *Rhizomorpha corynephora*. A, Coll. N. Funck and L. G. Schlim, Voyage Linden, Venezuela, 1841, in the Brussels herbarium. B, coll. E. Ule, Amazonas, Brazil, 1900, in Sydow, *Fungi Exotici Exsiccati*, no. 550.

sorts of intermediate conditions and forms between *Diatrype* and *Eutypella*. *E. sheuriana* should be reduced to synonymy with *D. albopruinosa*.

*Diatrype durieui* Mont. on the basis of specimens so labelled in the Curtis herbarium was considered by Ellis and Everhart (No. Amer. Pyren. 570. 1892) as a further synonym of *D. albopruinosa*.



This species according to Berlese (l. c.) is a totally different fungus. The synonymy is as follows:

STATATYPE ALBOPRUINOSA (Schw.) Cke. Grev. 13: 37. 1884.

*Sphaeria albopruinosa* Schw. Syn. Fung. Am. Bor. 195, no. 1238. 1832.

*Eutypella sheariana* Berl. Icon. Fung. 3: 68. 1905.

### 33. ROSELLINIA CUTICULARIS (Schw.) Ell. & Ev.

This was described by Schweinitz (Syn. Fung. Am. Bor. 210, no. 1505. 1832) as follows:

1505. 360. *S. CUTICULARIS*, L.v.S., passim in cortice denudato Bethl. affinis priori, sed tamen sequentibus notis distincta. *S. simplex*, subiculo insidens cuticulari splendente-candido vix manifestum floccoso, longitudinaliter effuso angusto, non pulverulento. Peritheciis subsparsis hemisphaericis atro-nitidis, papillatis. Magnitudine prioris.

A very small specimen with this name is found in Schweinitz' mounted collection at the Philadelphia Academy. It shows a few superficial scattered to united perithecia on the surface of rotten wood and agrees with his description. This is the only specimen that has been located. It is not mentioned by Fries, nor is it listed by Curtis as in his herbarium. It is not checked in Berkeley's copy of Schweinitz' Synopsis Fungi Amer. Bor. as having been seen by him. There is no specimen in the Collins' set of Schweinitz' fungi, nor in the Michener herbarium. No one seems to have seen the spores of this heretofore. Ellis (No. Amer. Pyren. 175. 1892) says "We find no measurements of the sporidia of this species." A slide from the Schweinitz' specimen at the Philadelphia Academy cited above shows about a half dozen free spores  $12-13 \times 6-7 \mu$  having the same appearance as those of *Rosellinia subiculata* (Schw.) Sacc., originally described by Schweinitz (Synopsis fungorum Carolinianae superioris, 44. 1822) as *Sphaeria subiculata*. It is evident that *S. cuticularis* is a mere form or condition of *R. subiculata* in which the subiculum has all disappeared except a thin whitish crust or "cuticle." I have collected excellent specimens showing this condition of the subiculum, but all intermediate forms are found.

Berkeley (Grev. 4: 52. 1875) cites the species as *Hypoxylon subiculosum*. Cooke in his Synopsis Pyrenomycetum (Grev. 15:

124. 1887) calls it *Byssosphaeria cuticularis* and lists it under "Species dubiae" without spore measurements. Ellis and Everhart (l. c.) refer it to *Rosellinia cuticularis* (Schw.). Specimens are found in the following Exsiccati: Ravenel, Fungi Amer. Exsic., nos. 650, 743, as *Hypoxylon subiculosum*; Ravenel, Fungi Car., no. 72, as *Sphaeria subiculata*; Ellis, North Amer. Fungi, no. 182, as *Sphaeria subiculata*.

#### 34. SPHAERIA ATROFUSCA Schw.

Schweinitz (Syn. Fung. Am. Bor. 206, No. 1429. 1832. Nec Fr, nec Berk. & Curt.) in his discussion of this species mentions only one gathering of it. This was on *Staphylea trifolia* from Bethlehem, Pa. Fortunately parts of this specimen, bearing good perithecia agreeing with the description, are available in Schweinitz' original packet, as well as in his mounted collection and the Collins' herbarium, all at the Philadelphia Academy. There are also portions of the type collection in the herbaria of Berkeley, Curtis, Fries, and Michener.

In 1885 Ellis examined Schweinitz' type at Philadelphia and reported (Jour. Myc. 1: 140. 1885) that he found it to be a *Nectria*, with spores  $10-12 \times 4.5 \mu$ . Cooke (Grev. 20: 85. 1892) examined that part of the type deposited in Berkeley's herbarium at Kew and found it to be also a *Nectria* with spores  $10-12 \times 4 \mu$ . Starbäck (Bih. K. Svenska Vet.-Akad. Handl. Bd. 19, Afd. III, No. 2: 94, pl. 4, fig. 73. 1894) records the results of his study of a specimen of this species which Schweinitz sent to Fries. He found mostly a pycnidial fungus which he referred to *Pseudodiplodia* as *P. atrofusca* (Schw.) Starb. In his copy of Schweinitz' *Synopsis Fungorum in America Boreali* at the Farlow Herbarium, Curtis has written opposite Schweinitz' no. 1429 "=*Nectria*."

We have examined that part of the type which is still in Schweinitz' original packet and find only the *Nectria* reported by Ellis, Cooke, and Curtis. The same is true of other portions of the type collection found in the Collins' and Michener herbaria. All have ascospores  $13-15 \times 4-5 \mu$ , somewhat larger than the measurements given by Ellis and Cooke.

Seymour (Host Index of the Fungi of North America 473.

1929) records Schweinitz' species on *Staphylea trifolia* with the following synonymy:

*Creonectria atrofusca* (Schw.) Seaver  
*Melogramma atrofuscum* (Schw.) Cke.  
*Nectria atrofusca* (Schw.) Ell. & Ev.  
*Pseudodiplodia atrofusca* (Schw.) Starb.  
*Sphaeria atrofusca* Schw.  
*Valsaria atrofusca* (Schw.) Sacc."

*Creonectria atrofusca* (Schw.) Seaver. This combination was made by Seaver (Mycologia 1: 186. 1909), who based it on a specimen collected by Everhart at West Chester, Pennsylvania, and issued as No. 1547 in Ellis and Everhart's North American Fungi. This is the true *Sphaeria atrofusca* of Schweinitz. The writer does not regard *Creonectria* as a valid genus.

*Melogramma atrofuscum* (Schw.) Cke. This name is apparently based on Cooke's reference (Grev. 15: 80. 1887) to "*Melogramma* (*Valsaria*) *atrofusca* Schw. Sacc. Syll. no. 4227, Herb. Berk. no. 9925. Sporidia uniseptata 10-12  $\mu$  long." Sacc. no. 4227 [Syll. Fung. 2: 391. 1893] cited by Cooke is a literal copy of Schweinitz' original description of *Sphaeria atrofusca* from his Syn. Am. Bor. Specimen no. 9925 from the Berkeley herbarium from which Cooke's description of the spores was made has not been seen, but it must have had colored spores to be referred to *Melogramma* or *Valsaria* and hence could not be the same fungus as *Nectria atrofusca* (Schw.) Ell. & Ev. This is not *Melogramma atrofusca* (Berk. & Curt.) Cke. in Grev. 13: 108. 1885 which equals *Anthostoma atrofuscum* Berl. & Vogl. This latter binomial is discussed under *Hypoxyylon* in an article in Lloydia 8: 258. 1945.

*Nectria atrofusca* (Schw.) Ell. & Ev. This combination by Ellis and Everhart (Jour. Myc. 1: 140. 1885) was based on the study of a specimen from Schweinitz' herbarium which is part of the true type.

*Pseudodiplodia atrofusca* (Schw.) Starb. Starbäck (l. c.) based this binomial on his examination of a specimen of Schweinitz' found in Fries' herbarium. He says that he found mostly *Pseudodiplodia* on this specimen, but also a little of the *Nectria* described by Ellis and Everhart. He suggests that the *Pseudo-*

*diploidia* may be the pycnidial form of the *Nectria*. Until this is demonstrated by pure culture studies, the pycnidial fungus Starbäck saw cannot be considered as belonging to Schweinitz' species.

*Valsaria atrofusca* (Schw.) Sacc. This name, cited by Seymour (l. c.), is based on Saccardo's use of the name (Syll. Fung. 9: 759. 1891) which he cites as "*Valsaria atro-fusca* (Schw.) Cke. in Grev. *Sphaeria* Schw., Herb. Berk. n. 9925." The Grevillea reference (Grev. 15: 80. 1889) referred to here by Saccardo is that in which Cooke uses the combination *Melogramma* (*Valsaria*) *atrofusca* as discussed above under *Melogramma*.

The following specimens of *Nectria atrofusca* (Schw.) E. & E. are present in the Mycological Collections of the Bureau of Plant Industry: Ellis and Everhårt, No. Amer. Fungi, no. 1547, coll. B. M. Everhart, West Chester, Pa., 1885; C. L. Shear, Plummer's Island, Maryland, 1903, C. L. Shear, no. 6054, Herndon, Va., 1926; Mason and Diehl, Fairfax Co., Va., 1931; Schweinitz, Bethlehem, Pa., in herb. Michener (as *Sphaeria*). All these specimens are on *Staphylea trifolia*.

### 35. SPHAERIA ATROFUSCA Fr.

Fries (Summa Veg. Scand. 388. 1849) listed this as a new species (item no. 7) under his section Byssisedae of *Sphaeria* but without description, so that it is a *nomen nudum*. Starbäck (Bih. K. Svenska Vet.-Akad. Handl. Bd. 19, Afd. III, no. 2: 38. 1894) after studying Fries' type, reduced the name to synonymy under *Lasiosphaeria racodium* (Pers.) Starb.

### 36. RHIZOMORPHA CORYNEPHORA Kunze

This name first appeared on the printed labels of specimens collected by Chr. Weigelt in Surinam in 1827 and issued in the first century of his Exsiccati in 1828. The fungi in this set were named by Kunze. The only specimen of the original collection we have seen is that part of the one found in Schweinitz' herbarium at the Philadelphia Academy which is now in the Michener herbarium in the Mycological Collections of the Bureau of Plant Industry. It is labelled as follows: "*Rhizomorpha corynephora* Kze. *Isaria arbuscula* Schw. mss. ad viva plant. Surinam." Some of the printed

labels of Weigelt's *exsiccati*, as determined by Kunze, are accompanied by diagnoses and some are not. We have not seen the original label of this species, but have found no evidence that it bore a description. Even if it did, it would not be valid under the rules of botanical nomenclature, as but few sets of this were distributed.

The next mention of the fungus is by Montagne (Ann. Sci. Nat. Bot. (sér. II) 14: 331. 1840), who listed it as follows, "*Rhizomorpha corynecarpus* Kze. in Weig. Surin. exsic.—Lepr. Coll. 688." Whether Montagne is responsible for the change of specific name from *corynephora* to *corynecarpus*, we do not know. This is the first use of this form of the name we have found.

In 1841 there was a Belgian expedition to Venezuela headed by Jean Jules Linden. Botanical specimens were collected by L. G. Schlim and N. Funck, the latter was the artist of the expedition. We have not seen the report of this expedition, but a brief account of it is given on page 9 of H. Pittier's article, *La evolución de las ciencias naturales y las exploraciones botánicas en Venezuela*, published in Caracas in 1920. We found in the Brussels herbarium a specimen of this fungus labelled "*Rhizomorpha corynephora* Kz. no. 394 Voy. Funck & Schlim, Caracas, Venezuela. 1841." The last part of the specific name had been crossed out and *carpos* written above. This is the ending used by Montagne in 1840 as cited above. A portion of this specimen is illustrated in figure 1.

Berkeley and Curtis on page 293 of their paper on *The Exotic Fungi from the Schweinitzian Herbarium, principally from Surinam* (Jour. Acad. Nat. Sci. Phila. 2 (n. ser.): 277-294. 1853) list the species as follows: "*Rhizomorpha coronephora* Kze. = *Isaria arbuscula* Schw. mss. A curious mycelium apparently common in Surinam." This statement is based on a portion of the original Weigelt collection brought to Schweinitz by Dr. Hering, the companion of Weigelt. Part of the Schweinitz specimen is in the Michener herbarium as already indicated. Berkeley and Curtis here give another spelling of the specific name with a different meaning, but probably only a typographical error.

Berkeley in his *Decades of Fungi* (Hooker's Jour. Bot. 8: 277. 1856) records the fungus as follows:

"*Rhizomorpha corynephora* Kze. Weig. Exs. Spruce n. 149. Hab. Panure. It is scarcely necessary to say that this is no autonomous fungus."

Streinz (Nomenclator fungorum, 501. 1862) lists *R. corynecarpus* Kze. as a synonym of *Cordierites guianensis* Mont. This is clearly an error as Montagne (l. c.) merely lists the *Rhizomorpha* as a separate item following *Cordierites*, with no evidence that he regarded them as synonymous. On the same page under no. 7984 Streinz lists *R. corynephora* Kze. as being found in Hostman's Cryptogamic exsiccati, no. 179, from Surinam. We have seen no specimens from this collection.

The next mention of the fungus is by Saccardo (Syll. Fung. 14: 1184. 1899) as follows:

"26. *Rhizomorpha corynephora* Kunze in Weig. Exs.; Berk. in Hook. Jour. (1856) 277 (absque diagnosi).

"Hab. ad truncos (?) Rio Javary, Panure Brasiliae."

Hennings (Hedwigia 43: 398. 1904) in his account of the Amazonian fungi collected by E. Ule lists and discusses this fungus as follows:

*Rhizomorpha corynephora* Kze. Weig. Exs.

Rio Jurua, Jurua-Miry und Marary: An Baumzweigen. September 1900, Mai 1901. No. 2726, 3095.

Die wunderbaren, korallenähnlichen Bildungen, deren Zusammengehörigkeit bisher völlig zweifelhaft ist, hängen in verzweigten bis  $\frac{1}{2}$  m. langen Büscheln von den Baumzweigen frei herunter und werden wie auch andere Rhizomorphenformen von den Vögeln zum Nesterbau benutzt. Ein derartiges Nest wurde von Herrn Ule an Ort und Stelle gesammelt. Die Rhizomorphen sind, aus dicht verflochtenen, gelblichen verholzten Hyphen bestehend, aussen mählig-filzig, reich verzweigt, die Zweige meist 1-2 mm. dick, mit dichtstehenden, oft abwechselnd langen, meist keulenförmigen stumpfen, mitunter an der Spitze verbreiterten oder geteilten 2-10 mm. langen, 1-3 mm. breiten kreidig-weißen, fast mählig-bestaubten Seitenästchen. Der Pilz ist den Bäumen äusserst schädlich, er tötet die Kronen derselben oft in weitem Umkreise völlig ab.

This is the first printed description of the fungus we have found and is therefore the date of its first valid publication. The Ule collections of 1900 and 1901 cited by Hennings, were issued in later years in exsiccati, the first by H. Sydow about 1923 (Fungi exotici exsiccati, no. 550) as "*R. corynecarpus* Kze. in Weigelt exsicc. (sine no.)," and the second by Ule himself in 1905 (Mycotheca brasiliensis, no. 100) as *R. corynephora* Kze. On the label of this specimen in the Mycological Collections of the Bureau of Plant In-

dustry the name had been changed in ink before being issued, presumably by Ule, to *corynecarpus*.

Hennings again (Hedwigia 48: 117. 1908) lists the fungus in his third paper on *Fungi Paraenses* as "*Rhizomorpha corynecarpus* Kze. in Weigelt Exs. 1827. *Rh. coryneclados* Kze.—*Rh. corynephorus* in Sacc. Syl. XIV, p. 1184." The reference in this case is based on a specimen collected by J. Huber, which we have not seen.

According to our studies as recorded above the fungus had been named by the several workers who have considered it as follows:

- 1828. *Rhizomorpha corynephora* Kunze in Weig. exsicc.
- 1840. *Rhizomorpha corynecarpus* Montagne Ann. Sci. Nat. Bot. (ser. II) 14: 331.
- 1841. *Rhizomorpha corynecarpus* Schlim and Funck in herb.
- 1853. *Rhizomorpha coronephora* Berkeley and Curtis Jour. Acad. Nat. Sci. Phil. 2: 293.
- 1856. *Rhizomorpha corynephora* Berkeley Hooker's Jour. Bot. 8: 227.
- 1862. *Rhizomorpha corynecarpus* Streinz, p. 501.
- 1899. *Rhizomorpha corynephora* Saccardo Syll. Fung. 14: 1184.
- 1904. *Rhizomorpha corynephora* Hennings Hedwigia 43: 398.
- 1908. *Rhizomorpha corynecarpus* Hennings Hedwigia 48: 117.

The valid name as already indicated is *Rhizomorpha corynephora* Kunze apud P. Hennings. 1904. The original form of the specific name as used by Kunze was *corynephora*, signifying the club-bearing rhizomorph. The name *corynecarpus* meaning club-fruited was attributed to Kunze by Montagne (l. c.), but we find no evidence that the former ever used it. Perhaps Montagne considered it more appropriate than Kunze's original. The form *coryneclados* used by Hennings has not been found elsewhere. It may be noted that the correct form of this specific epithet derived from the Greek should be *corynephora*.

The plant is of such a striking and unusual character that it is easily recognized. Figure 1 illustrates specimens from Venezuela and Brazil which agree with type material and show the variation in form and branching characteristic of the fungus. The large masses of yellow-white to gray rhizomorphs up to half a meter in length hanging from the branches of trees must make the fungus a conspicuous and attractive object. As a parasite it may have economic significance. It has been reported on guava and may well occur on other cultivated plants. No fructifications have been found by any of the collectors. The use of the specific name *corynecarpus*

by Montagne suggests that he may have regarded the club-shaped lateral branches as fructifications (FIG. 1).

In addition to specimens already discussed the following are to be found in the Mycological Collections of the Bureau of Plant Industry: Panyos, Guatemala, coll. O. F. Cook; Cabo Gracias a Dios, Nicaragua, F. A. Schramm, March 1923; Chagras, Panama Canal Zone, collector unknown, Sept. 1915; Panama Canal Zone, O. A. Barrett, 1915 on *Psidium guava*; Rio Madera, Brazil, J. R. Weir, Sept. 1923; Rio Madre de Dios, Bolivia, J. R. Weir, Oct. 1923.

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# THE IDENTITY OF PORIA MONTICOLA

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(WITH 1 FIGURE)

In 1920 Dr. Murrill (*Mycologia* 12: 90) described *Poria monticola* based on a collection made by J. R. Weir on *Pinus monticola* at Priest River, Idaho. Some 6 other collections were cited as representing the same species. Packets of all of these are preserved at New York and another lot at Washington. Of course, only the first mentioned is pertinent here. Also, there is a fragment from the packet in the Farlow Herbarium at Cambridge, marked, as other such fragments are marked at Cambridge, simply with the above data, without any reference to the origin of the specimen. I am indebted to Dr. J. L. Lowe of Syracuse University for calling my attention to this specimen.

Lloyd apparently was the first to examine the portion of the type collection at New York. He reported that it was only *Trametes serialis*. I have no record of when I first examined this collection, but it was not long after Lloyd reported on it, and it may have preceded his report. I, likewise, set it down as belonging to the *T. serialis* complex, because of the similarity of the spores I found, and other characters, that were obviously the same. The spores of *T. serialis* are rather characteristic, being elongated, pointed at one or both ends, and measuring  $7-8 \times 1.5-2.5 \mu$ . I may add at this point that *T. heteromorpha* usually differs from this species not only in the size of the pores but also in spore size, the spores of that species typically measuring  $9-14 \times 4-6 \mu$ . Likewise *T. serialis* is also frequently confused with *T. variiformis* Peck but again can with most certainty be separated on spore size, these being  $5-8 \times 2-3 \mu$ . Of course, all of these measurements can be arranged in a progressive series and the conclusion drawn that they are all variants of a common polymorphic species. They all inhabit

<sup>1</sup> Dr. Overholts died Sunday, November 10, 1946. This paper is therefore published with editorial corrections only. A. H. Smith.



FIG. 1. Photo of entire collection (type) of *Poria monticola* Murr. as preserved at New York. The specimen at the left is *T. serialis*, that on the right *P. monticola*.  $\times 1\frac{1}{4}$ .

the same woods, produce the same type of rot, and are equally ubiquitous and widespread. Forest pathologists are interested in these species from the decay standpoint, and the group has been much in the minds of investigators recently, and I take this opportunity to present my views on their status. Even *Trametes sepium* may well enter into the discussion since occasionally it is found on conifers, produces the same type of decay, and when in resupinate condition (as it usually is on these substrata) can be distinguished only by reference to its spores. The spores of *T. sepium* are of about the length of those of *T. heteromorpha* but are narrower, measuring  $8-11 \times 3.5-4.5 \mu$ .

\* In the course of some cooperative investigations with me in the genus *Poria*, Dr. Lowe spent considerable time in my laboratory recently and then went to the Farlow Herbarium to continue the work. Among the specimens studied at Cambridge was the

fragment of the type collection of *Poria monticola*. After going over its characters as represented by this fragment he queried me as to how it differed from *P. microspora*—a name proposed by me for a fungus which has been confused with *T. serialis* but which differs in having entirely different spores as well as in other characters as set forth in the original description in a paper by Dr. Nobles where the species was originally published (Can. Jour. Res. C 21: 220. 1943).

Since my own conception of the autonomy of *P. monticola* was involved, I at once sent for the type collection of Murrill's species as preserved at New York. Briefly, what I found was as follows.

This collection (FIG. 1) consists at the present time of two specimens. The larger specimen is *T. serialis*; spores and hyphae are in complete agreement. The smaller and wholly insignificant and quite inadequate specimen has all the characters of *Poria microspora*. I think a glance at the photo of the two specimens is enough to excuse both Lloyd and myself for the error into which we were led in referring the species to *T. serialis*. There is in the packet a spore print on a piece of black paper and when these spores are examined they are found to be typical of those of *P. microspora*, and spore data for the original description of *P. monticola* were undoubtedly taken from that source. Relying on my own ability to gather spore data from the specimen that was sectioned, I did not examine spores from the spore print of the real *P. monticola* specimen, else I would probably have noted the discrepancy.

The other collections, all by Dr. Weir, with the types of *P. monticola* at New York are a different matter. In the absence of spores it is sometimes not easy to decide the identity of specimens belonging to this group. Such is the condition of the two other packets mounted on the same sheet with the type packet at New York.

At any rate, Murrill's name must replace *P. microspora* recently described by me, and I hereby offer my deepest apologies to that individual for my (unpremeditated) attempts to suppress his species and to reduce it to a condition of "innocuous desuetude."

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# CLAUDOPUS VARIABILIS ON GRAY DUCK FROM SHADED AERIAL EXPOSURE IN PANAMA

ROBERT K. ZUCK

(WITH 1 FIGURE)

It has been pointed out in a previous paper (3) that species of angiocarpous fungi with dark hyphae are associated with the decomposition of cellulose in gray cotton duck during unshaded aerial exposure without ground contact. Consequently, the presence of sporophores of *Claudopus variabilis* (Fr.) Gillet on gray duck exposed in the Panama jungle is of considerable interest. The fabric samples were exposed on horizontal racks for three months, August 25, 1945–November 25, 1945, when the sporophores were discovered on the under surfaces. The photograph (FIG. 1) shows that the mycelium associated with the sporophores is white in color, and has invaded and decolorized the fungal colonies with dark hyphae.

This appears to be the first report of basidiomycetous sporophores found fruiting on gray duck during aerial exposure without ground contact. The low light intensity and exposure during the rainy season are considered to be of primary importance in the growth and fruiting of this fungus on the cloth.

Thom and Phillips (2) report high percentages of lignin in the several species of fungi with dark hyphae tested by them. In some instances, as much as twenty-nine per cent of the dry weight of the fungus was lignin. This work is further substantiated by Pinck and Allison (1) working with additional species of fungi. It is suggested that *C. variabilis*, which ordinarily grows on wood, may utilize the lignin and other constituents of the fungi with dark hyphae present on the cloth, as well as the cellulose of the fibers. The white areas produced by *C. variabilis* on the gray duck are much weaker than the areas invaded by the dark colored fungi. The entire exposed sample is very much weakened in comparison with the original.

The collection of the material was made while the author was on temporary duty with the Quartermaster Corps of the U. S. Army

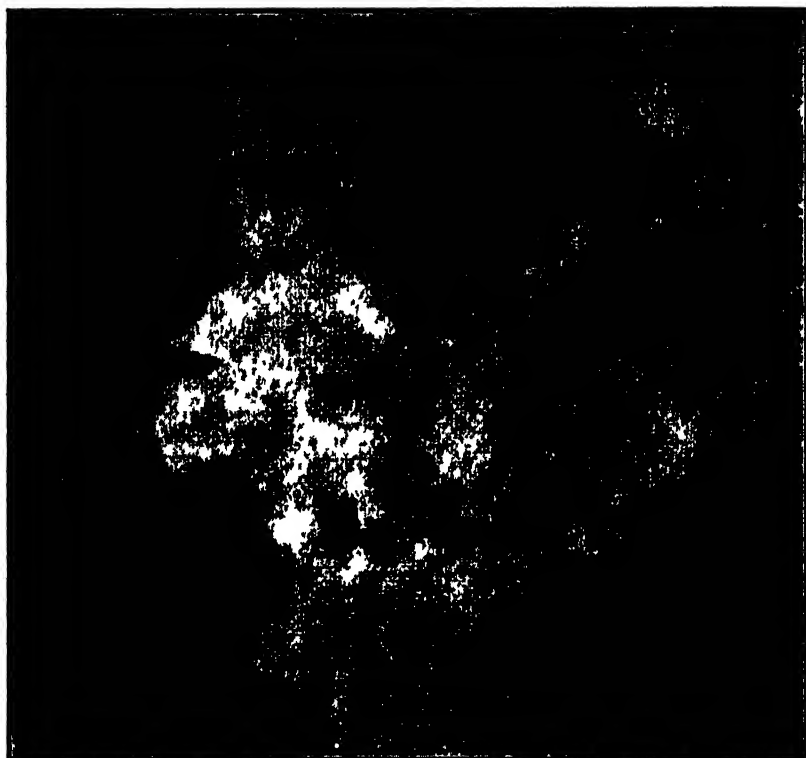


FIG. 1. Sporophores of *Claudopus variabilis* on gray duck  $\times 1$ .  
Photograph by Mr M. L. Jaeger

in Panama. *C. variabilis* was determined in conjunction with Dr. Wm. W. Diehl of the Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S.D.A. A specimen of the fabric with sporophores has been deposited with the mycological collections of the Bureau.

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# KERNIA, A NEW GENUS OF THE UREDINALES

M. J. THIRUMALACHAR

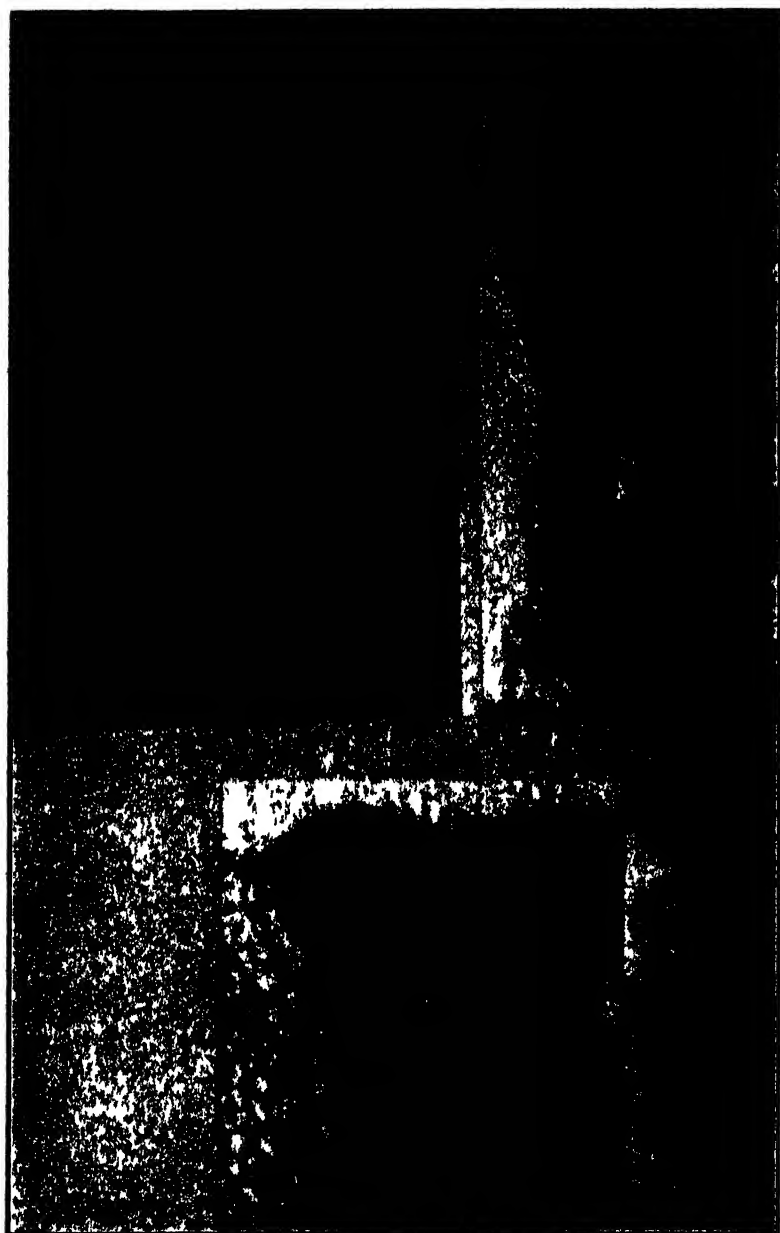
(WITH 9 FIGURES)

In a recent collection of rusts made by the writer near Mercara, Coorg, South India, a leaf rust on a species of *Litsea* (Lauraceae) was observed which on examination proved to be of great interest. The rust is foliicolous and hypophyllous developing small hypertrophied cushions from which numerous *Cronartium*-like spore columns emerge (FIG. 1). When these spore columns are grouped in close proximity they present the false appearance of tomentose outgrowths from the leaf surface.

The material for microscopic study was fixed in formalin-acetic alcohol and microtome sections of 10 to 12  $\mu$  thickness were cut and stained with Newton's iodine gentian violet.

The infection spot is visible on the upper surface as spherical to irregular discoloration spots. The rust is strictly hypophyllous but on rare occasions infections were observed on tender shoots and petioles. The infection spot on the lower surface first appears as a tiny greenish-yellow pustule and gradually enlarges into a discoid hypertrophied cushion of five to eight millimeters in diameter. The margin of the infection spot is sharply delimited from the rest of the leaf surface.

The rust is a microcyclic form with telia only. Pycnia have not been noticed in any of the collections and it seems probable that they are absent in the life-cycle. The sori are deep seated within the host tissue beginning their development a short distance beneath the palisade layer and growing out towards the lower epidermis. The initials of the telium are organized beneath the palisade layer by the grouping of coarse hyphae. Mature sori are cupulate like an aecial cup and lined with a fine hyphal layer (FIGS. 3, 4). Peridial cells or paraphyses have never been noticed. The host cells

FIGS. 1-3. *Kernia Lauricola*.

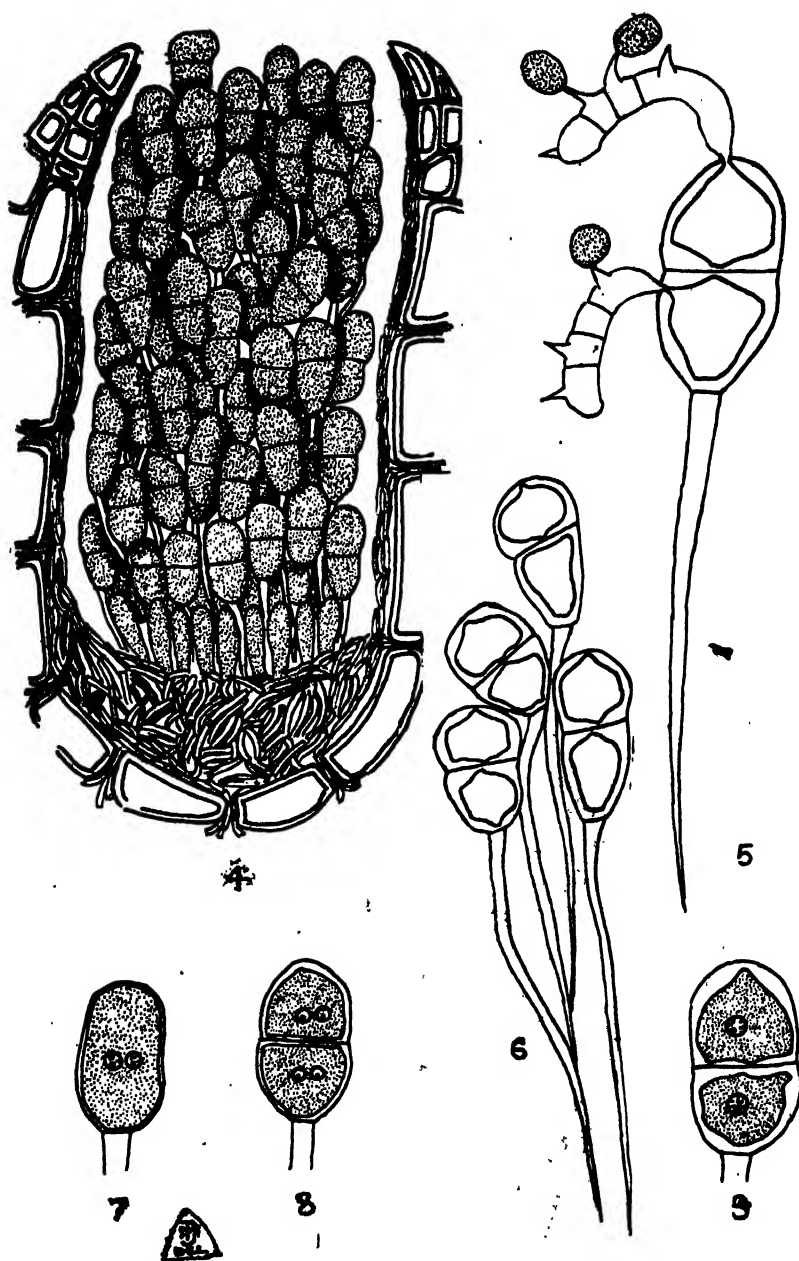
bordering the mouth of the sorus form a rim of elevated tissue which possibly afford additional support for the spore columns.

Teliospores develop continuously from the base of the sori in a manner characteristic of the tribe *Puccinosirae* of Dietel (1928). As each spore is formed from the base of the sorus it becomes detached and is pushed upwards by the younger spores developing around and below it. The mature spores are two-celled, pedicellate and *Puccinia*-like. The spores are definitely not catenate but the younger spores are formed between the older ones (FIG. 6). As spores are produced in rapid succession they get closely adpressed to one another and are pushed out of the sorus in long brownish-black spore columns giving the characteristic appearance of the spore columns of *Cronartium*, *Crossopora*, *Masseella* and others. The spore columns are cylindrical and semi-permanent to the extent that the spores in the columns could be separated only with pressure.

The developmental stages of the teliospore are as follows: a binucleate hyaline teliospore initial borne on a basal cell is first differentiated. Following a nuclear division, the teliospore initial gives rise to a uniseptate *Puccinia*-like spore. As the spore matures the original basal cell elongates into a long pedicel measuring up to  $137\ \mu$  and becomes detached from the basal hymenium. The wall of the spore is thickened and turns yellowish-brown. The two nuclei in each cell of the spore fuse to form a syncaryon (FIGS. 7 to 9). The episporium is smooth and reveals a distinct germ pore in each cell. The pedicels are up to  $137\ \mu$  long, and  $4\ \mu$  broad at the point of attachment to the spore but gradually taper into a fine point at the base. The pedicels of the upper tiers of spores inarch over the teliospores at the base and appear closely adpressed to them. It is probable that this provides additional firmness to the spore column. The spore columns are mostly ten to fifteen millimeters in length and resemble in the mode of spore formation the genus *Skierka* Racib.

The teliospores germinate at maturity without a period of rest. When an intact spore column and sorus was observed, the germinating spores were noticed just above the mouth of the sorus. The promycelium emerges as a small papilla and gradually elongates, becoming cylindric and recurved. Later on it becomes four-



FIGS. 4-9. *Kernia Lauricola*.

celled and develops globular sporidia at the tips of the sterigmata (FIG. 5). Cytological studies reveal that the sporidia are all uni-nucleate.

The occurrence of the rust on the leaves of *Litsea* producing hypertrophied cushions and developing two-celled *Puccinia*-like spores immediately brings to mind the characters of the genus *Xenostele* described by Sydow (1920) on the two Lauraceous hosts *Litsea* and *Actinodaphne*. The sori in this genus are cupulate and lined with a well developed peridial layer which led previous workers to mistake the two rusts for species of *Aecidium*. Though the rust under investigation occurs on Lauraceae, the complete lack of any peridium clearly distinguishes it from *Xenostele*. Further, the long spore columns are not known to occur in the two species of *Xenostele* so far recorded.

Long *Cronartium*-like spore columns composed of two-celled teliospores are known to occur in the genera *Gambleola* Masee, *Didymopsora* Diet. and *Puccinosira* Lagerh. *Gambleola* is a monotypic genus on the leaves of *Berberis nepalensis* developing long hair-like teliospore columns. The spores are produced in catenations, the sterile intercalary cells simulating pedicels for the teliospores. The presence of a single layer of peridium surrounding the telial columns was pointed out by Jackson (1931) and confirmed again by the writer (Thirumalachar, 1946). The lack of any such peridial layers or catenate teliospores clearly distinguishes the rust under study from *Gambleola*.

The genus *Didymopsora* founded by Dietel (1899) is characterized by the presence of short telial columns of few millimeters. The spores are produced in chains and are sessile. In many cases the two cells of the spores show tendencies to get separated. Likewise, the genus *Puccinosira* possesses two-celled teliospores which are produced in catenations. There is a well developed peridial layer lining the sorus, and in many species the occurrence of intercalary cells separating spores are present. The rust under investigation differs entirely from the two abovementioned genera in the type of spore column produced and in having pedicellate teliospores. The genus *Gymnosporangium* Hedwig. also possesses two-celled pedicellate teliospores emerging in variously shaped gelatinous spore horns. The jelly-like matrix in which the spores

appear to be embedded as well as other characters clearly distinguish the genus from the rust collected by the writer on *Litsea*.

In the shape of the spore columns, and probably in the mode of spore development, there appears to be a close resemblance between the rust under study and the genus *Chardoniella* described by Kern (1939) on a species of *Gynoxis* collected in Colombia. This rust produces telial columns, as in *Cronartium* or *Cionothrix*, with one-celled pedicellate teliospores developed within deeply seated non-peridiate sori. The spore columns are produced by the lateral adpression of the teliospores to one another. Kern does not definitely state whether the teliospores are catenate or not, though his figures might be taken as indicating that the younger spores are produced between the older ones. This feature is very evident in the genus *Skierka* investigated in detail recently by Mains (1939). Here the young teliospores are produced between the older ones and long semi-permanent teliospore columns are supported by the close grouping of the spores. The rust under study, although closely agreeing with *Chardoniella* in all essential features, differs from it in having two-celled instead of the one-celled teliospores. As it cannot be accommodated in any of the genera so far described, the writer proposes to present it as a new genus with the name *Kernia*, named in honor of Prof. F. D. Kern, of the Pennsylvania State College, distinguished American Uredinologist who has advanced our knowledge of the tropical rust fungi.

***Kernia* Thirumalachar gen. nov.**

Pycnia, aecia atque uredia ignota. Telia subepidermalia, erumpentia, alte infixa in texturis plantae parasitatae, absque peridiis vel paraphysibus, producentia sporas 2-cellulatas, *Pucciniae* similes, pedicellatas successive, quae sporae non sunt catenatae, sed juniores teliosporae seniores inter evolvuntur, lateraliter inter se adhaerentes, sporarum massa emergente *Cronartii* instar in longas, semi-permanentes sporarum columnas 10-15 mm. longas; sporae germinant in maturitatae absque ulla quiescentiae mora, promycelio externo atque 4-cellulato.

Species typica: *Kernia Lauricola* Thirumalachar.

Pycnia, aecia and uredia unknown. Telia subepidermal, erumpent, deep seated within the host tissue, without peridia or paraphyses, developing *Puccinia*-like, two-celled pedicellate spores in succession, which are not catenate but the younger teliospores developing between the older, adhering laterally to one another, spore

mass emerging out in long, semi-permanent *Cronartium*-like spore tendrils or columns, 10 to 15 mm. long; mature spores germinating without a rest period; promycelium external and four-celled.

TYPE SPECIES: *Kernia Lauricola* Thirumalachar.

***Kernia Lauricola* Thirumalachar sp. nov.**

Pycnia aecia et uredia ignota. Telia hypophylla, simul aggregata in tumescentes, hypertrophisatas maculas gallis similes, 5-8 mm., subepidermalis, erumpentia, pluribus teliosporis *Puccinia*-similibus, 2-cellulatis, pedicellatis, simul aggregatis in semipermanentes sporarum columnas *Cronartio* similes; hae columnae sunt cylindricae, brunneo-nigrae, 10-15 mm. longae. Teliosorus alte infixus 160-200  $\mu$  latus, 280-340  $\mu$  profundus, absque peridiis vel paraphysibus, producens ad columnam adduntur. Teliosporae haud catenulatae, juniores spora inter seniores positae, atque illis lateraliter adhaerentes; 2-cellulatae, pedicellatae, luteo-brunneae, tenuiter angulares ob lateralem compressionem, tenuissime vel nullo modo constrictae ad septa, magnitudinis 30-44  $\times$  20-27.5  $\mu$ ; episporium inequaliter crassum, circa 3-6  $\mu$  crassitudine, leve, unico germinationis poro in singulis cellulis; pediculo hyalino, 112-137  $\mu$  longo, 3-4  $\mu$  lato, ad apicem, atque gradatim ad basim acuescente. Teliosporae statim in maturitatem germinant, promycelio externo, 4-cellulato, recurvo; sporidiis globularibus, hyalinis, magnitudinis 8-10  $\mu$  diam.

Hab. in foliis *Litsea* spec. indet., Sontikoppa Road, Mercara, Coorg, South India, 26-3-1946, leg. M. J. Thirumalachar, *Thirumalachar 1300*. Typus positus in Herb. Crypt. Ind. Orientalis, New Delhi; in Imperial Mycological Institute, Kew, Anglia; atque in Arthur Herb. in Purdue Universitate, Lafayette, Indiana, U. S. A.

Pycnia, aecia and uredia unknown. Telia hypophyllous, grouped together on swollen gall-like hypertrophied spots 5-8 mm. in diam., subepidermal, erumpent, with numerous *Puccinia*-like two-celled pedicellate teliospores massed together in semipermanent *Cronartium*-like spore tendrils or columns which are cylindric, brownish-black, and measure 10 to 15 mm. in length.; teliosorus deep seated, 160-200  $\mu$  wide and 280-340  $\mu$  deep, without peridia or paraphyses, developing in succession from the base teliospores which become free and add to the column basipetally; teliospores not catenulate, younger spores wedged in between the older ones and adhering laterally to one another, two-celled, pedicellate, yellowish-brown, slightly angular due to lateral compression, very slightly or not constricted at the septa, measuring 30-44  $\times$  20-27.5  $\mu$ , episore unequally thickened, between 3-6  $\mu$ , smooth, with a single distinct germ pore in each cell; pedicel hyaline, 112-137  $\mu$  long, 3-4  $\mu$  broad at the apex and gradually tapering off into a fine point at the base; teliospores germinating immediately at maturity; promycelium external, four-celled and recurved, sporidia globular, hyaline, measuring 8-10  $\mu$  in diam.

Hab. on the leaves of *Litsea* sp., Sontikoppa Road, Mercara, Coorg, South India, 26-3-1946, leg. M. J. Thirumalachar, *Thirumalachar 1300*. Type deposited in the Herb. Crypt. Ind. Orientalis, New Delhi; Imperial Mycological Institute, Kew, England, and in the Arthur Herbarium, Purdue University, Lafayette, Indiana, U. S. A.

In conclusion the writer wishes to express his deep sense of gratitude to Rev. Dr. H. Santapau, Professor of Botany, St. Xavier's College, Bombay, for kindly rendering into Latin the diagnoses of the genus and species and to Dr. L. N. Rao, Professor of Botany, Central College, Bangalore, for kind encouragement. This portion of the work was carried out by the writer as a Research Fellow of the University of Mysore.

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#### EXPLANATION OF FIGURES

FIG. 1. Showing the spore columns on the lower surface of the leaf, nat. size. FIG. 2. Photomicrograph of the spore column slightly crushed  $\times$  about 100. FIG. 3. Photomicrograph of the sorus  $\times$  about 100.

FIG. 4. Section through the telium showing the development of the spores  $\times$  200. FIG. 5. Germinating teliospore with external 4-celled promycelium and sporidia  $\times$  800. FIG. 6. Showing the arrangement of the teliospores in the column  $\times$  400. FIGS. 7 to 9. Showing the stages in the development of the teliospores  $\times$  600.

## TWO NEW SPECIES IN THE AGARICALES

ROLF SINGER

*Rhodocybe* Maire was originally proposed for species with pink, rough spores, and cystidia. The cystidia later (Singer, *Lloydia* 5: 110. 1942 and *Ann. Myc.* 51: 89. 1943) were found to be pseudocystidia, *i.e.*, cystidioid prolongations of the lactiferous system into the hymenium. In the same papers it was stated that *Rhodocybe* has clampless hyphae. Though the genus *Rhodopaxillus* Maire was generally believed to have clamp connections, it has been shown (*Lloydia* 5: 110. 1942) that no clamps occur in *Rhodopaxillus nuciolens*. After a careful check upon all species and specimens available, it appears that all species of *Rhodopaxillus*, section Nitellini Sing. and section Decurrentes Konrad & Maublanc, lack clamp connections, and according to Kühner, they have binucleate spores. This and the incrusting pigment encountered in all these species as well as in *Rhodocybe caclata* show that they differ from species of the latter genus merely in lacking the pseudocystidia. On the other hand, the typical species of *Rhodopaxillus* have intracellular pigment, constant clamp connections, and according to Kühner (*Bull. Soc. Linn. Lyon*, Sept. et Oct. 1945, nos. 7 et 8, p. 160-169), uninucleate spores. It appears, therefore, that the genus *Rhodocybe* should be emended. As emended it would consist of the sections Nitellinae (Sing.), Decurrentes (Konr. & Maubl.) and Genuinae Sing. (= *Rhodocybe* sensu originali). In South Florida a species of the Nitellinae has been found which differs from *Rhodocybe nitellina* (Fr.) Sing. comb. nov. [*Rhodopaxillus nitellinus* (Fr.) Sing.] as well as *Rhodocybe nuciolens* (Murr.) Sing. comb. nov. (*Melanoleuca nuciolens* Murr.) in having narrower and closer lamellae, clitocybeoid habit and less pigment, and it also differs from *R. nitellina* in having slightly smaller spores. It is possible that this new species which is designated *Rhodocybe alutacea* nob. is too close to one of Maire's African varieties of *Rhodocybe truncata* (Schaeff. ex Fr.) Sing. comb. nov.

(*Rhodopaxillus truncatus* (Schaeff. ex Fr.) Maire), viz. var. *mauretanicus* or var. *subvermicularis*, but in this case I would not consider them conspecific with *R. truncatus*.

***Rhodocybe alutacea* Sing. spec. nov.**

Pileo gilvulo ("light pinkish cinnamon" Ridgwayi ad marginem extremum, ceterum inter "pinkish cinnamon" et "cinnamon buff") in statu humido, hygrophano, pallidior vel albo in statu sicco (inter "pale pinkish buff" et "pinkish buff" vel pallidior), levi vel substriatulo prope marginem, sericello vel subglabro, glabrescente, convexo, umbilicato, 25–35 mm. lato; cuticula consistente ex hyphis filamentosis, defibulatis, pigmento, vix incrustatis, repentibus.—Lamellis subconcoloribus ("Light pinkish cinnamon"), angustissimis vel moderate angustis (1–3 mm. latis), confertis vel confertissimis, distincte decurrentibus sed subrotundatis ad stipitem; sporis sordide incarnato-hyalinis, ab apice visis rotundato-subangulatis *Clitopilorum* modo sed neque longitudinaliter venulosis nec subcanaliculatis sed verrucis irregularibus membrana incrassata formatis exasperatis, saepe collabentibus maturitate, ellipsoideis vel ellipsoideo-subangulatis sed a *Rhodophyllum* typo longe recedentibus,  $5.8-7.5 \times 3.8-4.5 \mu$ ; basidiis  $22-29 \times 6-7 \mu$ , tetrasporis; cystidiis nullis visis; tramate regulari, elementis filiformibus, tenuibus, parallelis vel subparallelis defibulatis composito. Stipite subconcolori ("light pinkish cinnamon" R.) vel albo, haud albo in, exsiccatis, sed semper albo ad basin, subpubescente vel glabro, glabrescente, villosa ad basin, levi, solido, subaequali,  $23-35 \times 2.5-5.5$  mm. Carne pilei stipitisque alba vel albida; odore farinaceo; sapore farinaceo mitique. Methyparamidophenol sine reactione. Ad humum sabulosum et ad folia delapsa; solitario in dumetis coniferis destitutis typi "low hammock" et "tropical hammock" in Augusto et Septembri mensibus. Florida meridionalis Dade Co. Simpson Park *F. 674* (FH); Matheson Hammock *F. 674a* (FH), *F. 908*, type (FH); Highlands Co., Highlands Hammock State Park, *F. 451* (FH).

The Laccarias with large spores and the species with comparatively small spores have been studied satisfactorily in the past, but there is a group of probably two species with intermediate spores, i.e., spores above  $10 \mu$  in diameter and with spines  $1.5-2.5 \mu$  long, but not reaching  $15 \mu$  and more closely resembling those of *L. echinospora* Speg. and *L. pumila* Fay. We are concerned here with two species, one studied in previous papers (Lloydia 5: 102. 1942; Mycologia 35: 151. 1943) as *L. striatula* Peck and *Clitocybe ohiensis* (Mont.) Sacc., the former being a synonym of the latter, and the other an undescribed form differing from *Laccaria ohiensis* (Mont.) Sing. comb. nov. (*Clitocybe ohiensis* Sacc.) in having four sterigmata on a basidium and being smaller in an average. Al-

though it is true that Lange was wrong in attributing specific value to the number of sterigmata in the agarics, as has been shown by numerous authors, among others A. H. Smith and R. Kühner in Mycenae, it does not appear to me to be desirable to insist that the number of sterigmata can never be of specific value. In the Laccarias, truly parallel forms (*i.e.*, forms with all characters in common excepting the number of sterigmata) have not been observed thus far, and although it is true that there are species with usually mixed basidia (1-2-3-4-spored basidia in the same specimen in *L. amethystina* are not rare), and although it is also true that the species with large spores are two-spored and those with small spores four-spored, there appears to be no real parallelism, and unless experimental studies show this hypothesis to be incorrect, I shall continue to assume that the bisporous forms of the Laccarias have become phylogenetically stable and correlated with additional small morphological characters that are constant; in other words that they have lost their original reversibility, and consequently their specific identity with the normal four-spored forms. With this reservation made the following fungus is described as a new species.

**Laccaria tetraspora** Sing. spec. nov.

Pileo hygrophano, pallide purpurascens-roseo in statu sicco, brunneolo-incarnato vel incarnato-roseo in statu humido, striato in statu humido, sulcato in statu sicco immo exsiccato, glabro vel fibrilloso, pellucido, convexo, dein applanato centroque depresso, in statu exsiccato umbilicato, saepe in statu vegeto etiam umbilicato, 10-20 mm. lato; cuticula paulum distincta, ex hyphis jacentibus elongatis efformata. Lamellis incarnato-roseis, latis, distantibus, adnato-decurrentibus, sporis pulveraceis; sporis hyalinis, fortiter echinatis, globosis, haud amyloideis,  $7.5-14 \times 7-13.5 \mu$ , plerumque circa  $11 \times 10 \mu$ , spinis pyramidalibus,  $1.5-2.5 \mu$  longis; basidiis tetrasporis,  $40-50 \times 11.5 \mu$ ; cystidiis nullis; cheilocystidiis praesentibus sed haud conspicuis; tramate admodum regulari, ex hyphis parallelis vel subparallelis elongatis, fibulatis consistente. Stipite subconcolori, subglabro, sicco, tomento myceliali albo haud fortiter evoluto, solido, aequali, vel base incrassato,  $10-30 \times 1.5-2.5$  mm. Carne subconcolori-pallidiore, subfragili, inodora, insipida. Ad marginem viarum prope paludes vel prope silvas densas, nec non in silvis praecipue frondosis ad terram calcio depauperatam, gregatim, Junio usque ad Octobrem mensem. In America ad litus Atlanticum dispersa. Massachusetts, Prospect Hill near Waltham *W. G. Farlow* (FH); New York, Adirondack Mts. *W. A. Merrill* "examined for North American Flora" ut *L. striatula* Peck



(NY); Van Cortland Park prope N. Y. City, *R. Singer* (NY); Florida, Highlands Hammock State Park, *R. Singer*, *F 160* (FH), *typus*; Uruguay, Dep. Montevideo, *Herter*, *1570* (*Plantae Uruguayenses Exsiccatae*), (FH), a much larger, otherwise identical form.

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# MINERAL OIL AS A FUNGUS CULTURE PRESERVATIVE

C. C. WERNHAM

Sherf<sup>1</sup> in 1943 reported on the successful use of mineral oil as a preservative of bacterial cultures. *Fusarium* and *Alternaria* spp. subjected to the same test survived the treatment at least six months (extent of test), without any apparent change in morphology. The bacterial cultures maintained their pathogenicity as well as their viability.

*Corynebacterium sepedonicum* (*Phytomonas sepedonica*), the causal organism of bacterial ring rot of the potato, is exceedingly difficult to maintain in culture. Sherf was encouraged to try mineral oil as a preservative by several reports in the bacteriological literature that liquid paraffin prolonged the life of bacterial cultures on artificial media. The fungous cultures mentioned above were carried along in the experiment.

The method essentially is as follows: make fresh transfers of the bacterial or fungous culture. After these have grown to produce the growth normally expected of a transfer (10 days) the cultures are covered with a layer of sterile mineral oil sufficient to extend well above the slant. The tubes are replugged with cotton and held at room temperature. Transfers are made by passing a loop through the oil, scooping up a loopful of the colony, withdrawing the loop and momentarily holding it against the side of the tube to drain off the excess oil, and streaking the oil-drained loopful to a new slant. It is assumed that a needle was used for the fungous cultures.

At the time Sherf's article appeared, the writer was faced with the problem of maintaining a number of fungous cultures in a common laboratory refrigerator which periodically became infested with mites. The mineral oil technique looked like a possible solution to a troublesome and irritating problem.

<sup>1</sup> Sherf, Arden F. A method for maintaining *Phytomonas sepedonica* in culture for long periods without transfer. *Phytopath.* 33: 330-332. 1943.

Four corn pathogens were selected for the experiment: *Diplodia* ~~seae~~, *Gibberella* ~~seae~~, *Cochliobolus heterostrophus* (*Helminthosporium maydis*) and *Nigrospora oryzae*. *Gibberella* and *Nigrospora* were completely submerged, the oil extending a full inch above the tip of the slant. *Diplodia* and *Helminthosporium* were covered to the extent of the lower portion of the slant. The slants of these latter two soon dried away from the test tube leaving the too familiar agar chip hanging to the edge of the tube. The fungous growth remained glistening with oil and proved easy of transfer. The former two cultures retained the normal slant of the freshly prepared culture. All cultures were retained at room temperature.

Transfers were made to fresh corn meal agar slants every three months. On March 15, 1946, these cultures had survived the treatment exactly two years.

At the end of 15 months the *Diplodia* and *Gibberella* cultures were used to prepare inoculum for field inoculations. There was no evidence of loss in pathogenicity. At the end of 23 months *H. maydis* was used to inoculate seedling corn plants in the greenhouse. Abundant infection resulted and the fungus was reisolated from the seedling leaves. Pathogenicity tests of the other fungi will be conducted during the summer.

These results have been so encouraging that the writer now keeps all his stock cultures under mineral oil. It is hoped that this note may encourage a wider use of Sherf's technique. I shall be glad to furnish subcultures of these fungi to anyone interested in checking the results herein reported.

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# THE CHROMOSOMES OF *NEUROSPORA* *TETRASPERMA*<sup>1</sup>

VICTOR M. CUTTER, JR.

(WITH 1 FIGURE)

A comparison of McClintock's recent report (1945) on the structure and number of chromosomes in *Neurospora crassa* Shear & Dodge with earlier studies on this and related species brings out the possibility that significant variation exists in the morphology of the chromosomes of this genus. The present widespread interest in the physiological genetics of *Neurospora* emphasizes the need of an intensive cytological confirmation of pertinent genetic data in this genus. McClintock's study contrasted with other cytological investigations on the Ascomycetes may also lead to the conclusion that *N. crassa* is unique among fungi in possessing meiotic chromosomes large enough for easy study. However, her results were obtained with smear techniques not available to earlier workers in this field, and it is possible that these divergent reports are due to the use of different methods of preparation rather than to inherent differences in the species themselves. The purpose of this study is to investigate another species of *Neurospora* by similar smear techniques in order to determine whether the reported differences in the chromosomes are real or artifactual.

McClintock has reported a number of strains of *N. crassa* with seven haploid chromosomes. Beadle (1946), on McClintock's authority, also cites the haploid number as seven in this species whereas Lindegren and Rumann (1938) had previously reported its haploid number as six to nine. In the closely related eight spored species, *N. sitophila* Shear & Dodge, Wilcox (1928) figures six haploid chromosomes. Dodge (1927) does not state the chromosome number in the homothallic four spored species *N. tetrasperma* Shear & Dodge, but his figures lead to the conclusion that

<sup>1</sup> This work was partially summarized before the Microbiological Section of the Botanical Society of America at St. Louis, Mo., March 1946.

five or six haploid chromosomes were present in the strain he studied. Colson (1934) found six chromosomes in *N. tetrasperma*, while McClintock (1945) on the basis of unpublished observations reports seven haploid chromosomes in a strain of this species. A comparison of the figures published by these authors also suggests that differences occur in the morphology of the chromosomes of the various species and strains. This variability is of some theoretical interest since it implies that chromosome number and structure may be used as a clue to speciation in this genus.

*N. tetrasperma* was chosen to initiate this study because there were available for comparison the previous investigations of Dodge and Colson. This species is favorable for cytologic work since it is homothallic and readily forms abundant large perithecia with well developed asci. No attempt will be made to review the details of nuclear behavior throughout the life cycle since these have been adequately described by Dodge and Colson, and no further information of this type was obtained. Attention will be confined to the structure of the chromosomes as revealed in smears. All preparations were smeared and stained with aceto-carmine or aceto-orcin by the methods of McClintock (1945) and Cutter (1946). The fungus was cultured upon corn meal decoction agar or potato-dextrose agar made up according to the usual formulas. Perithecia containing asci in all stages of development were fixed and smeared seven to fourteen days after inoculation of the cultures. The culture used was obtained from the culture collection of the Department of Plant Pathology of the University of Minnesota through the kindness of Mr. C. W. Roane.

The somatic nuclei in the hyphae and conidia of this species are small and unexpanded (FIG. 1 U). Since aceto-carmine does not stain the spindle substance the chromatic masses stand out clearly during mitosis and this stain is very favorable for a study of such nuclei. The cytologic fixatives and stains commonly used in fungus work cause shrinkage of the chromatin and a clumping of the chromosomes in these unexpanded nuclei with resulting artifacts which have been frequently reported as amitoses. The chromosomes in somatic divisions are rarely more than a micron in length but they may be counted in properly oriented metaphase figures. The six chromosomes are quite uniform in length and configuration,

FIG 1. Chromosomes of *Neurospora tetrasperma*

but little can be determined about their structure. On the other hand the somatic nuclei of the sterile paraphyses and the basal cells of the hymenium are expanded and in these cells metaphase figures showing six chromosomes are easily interpreted (FIG 1 V).

After syngamy in the young ascus of *N. tetrasperma* three nuclear divisions occur which result in the formation of eight nuclei. Ascospore walls are then delimited and two nuclei are incorporated in each of four spores (FIG. 1 R). Occasionally spore walls are

formed at the conclusion of the second division in which case the third and fourth mitoses are carried out within the spore membrane (FIG. 1 Q). Normally only the fourth mitosis takes place after ascospore wall formation. At maturity the ascospores are quadrinucleate and bisexual or homothallic.

Twelve very slender and somewhat contracted leptotene strands may be distinguished as the presynaptic fusion nucleus begins to expand following syngamy (FIG. 1 C, D). At this time prominent masses of chondriosomes are apparent in the tips of the asci and these presumably function in the accumulation of the oily materials in these regions. The leptotene strands pair rapidly and are so closely appressed during the early synaptic period that the doubled condition of the chromosomes is difficult to detect. At this time also the chromomeres enlarge and the synapsed chromosomes appear prominently beaded (FIG. 1 E, F, G). A bouquet arrangement of the chromosomes with the spindle attachment regions grouped close to the nuclear membrane (FIG. 1 H), is rather common during the zygotene and early pachytene stages. Two of the six pachytene chromosomes are noticeably longer than their mates. During their extreme elongation these two chromosomes may reach a calculated length of eight to ten micra. This is shorter than the lengths reported by McClintock for the corresponding first and second chromosome in *N. crassa*. One of these long chromosomes serves as the nucleolus organizer and is provided with a minute satellite (FIG. 1 K). The remaining four chromosomes are quite uniform in length and configuration and in pachytene they reach a length of four to five micra. At diakinesis there are six bivalents and a prominent nucleolus within the nuclear membrane (FIG. 1 J, K). During metaphase or early anaphase the nucleolus drifts out of the nuclear vacuole and is lost in the cytoplasm.

Centromere position has not been calculated in this fungus. The nucleolus is large and frequently obscures portions of the chromosomes particularly during the first division in the ascus. No heteromorphic chromosome pairs were seen. The prophase chromosomes become shorter in each successive division in the ascus, but they maintain their relative configuration. During the third division very prominent nuclear beaks or "spindle horns" are developed (FIG. 1 P). The structure and function of these is well

described by Colson. At the completion of the fourth mitosis in the ascospores the nuclei contract rapidly and sink into the unexpanded state. At this time the central body or nucleolus appears eccentric within the membrane (FIG. 1 *S*). Shortly thereafter this central body is either cast out of the nucleus or loses its chromaticity, for in the unexpanded condition the nuclei are quite homogeneous in appearance (FIG. 1 *T*).

The results of this preliminary study confirm Colson's report of six haploid chromosomes in *N. tetrasperma*, and also emphasize the fact that chromosome morphology may provide a basis for studies on speciation in this genus and related ascomycetes. The chromosomes are sufficiently large for easy study, and they may offer very favorable material for a study of the chromosomal basis of homothallism.

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#### EXPLANATION OF FIGURES

All figures drawn with the aid of a camera lucida at an approximate magnification of  $\times 1300$ .

FIG. 1, *A-B*. Syngamy in young ascus hooks. *C-D*. Developing asci showing leptotene chromosomes. *E-K*. Stages in synapsis. Note bouquet arrangement of chromosomes in *H*. *J-K*. Diakinesis stages showing six



bivalents and nucleolus. In *K* the ascus has been crushed and the nuclear membrane ruptured. *L*. Metaphase I. *M*. Anaphase I. *N*. Prophase II late stage. *O*. Prophase III. *P*. Metaphase III, note nuclear beaks. *Q*. Third division stages in abnormal ascus where ascospore wall formation followed the second nuclear division. *R*. Fourth division stages in normal ascus where ascospore wall formation followed third nuclear division. *S-T*. Quadrinucleate ascospores in maturing asci. Note nuclei entering unexpanded state. *U*. Multinucleate macroconidia with unexpanded nuclei. *V*. Somatic mitoses in paraphysis.

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DECEASED

ERNST BERNHARDT  
ROBERT HAGELSTEIN  
D. H. LINDER  
L. O. OVERHOLTS

## RESIGNED

C. L. BEDFORD  
A. F. BLAKESLEE  
H. S. CONARD  
R. B. HARRIS  
F. D. HEALD  
H. C. JOHNSON  
E. M. MARTIN  
BERNICE SRAVER

News has just been received that both Dr. L. O. Overholts, of Pennsylvania State College and Dr. D. H. Linder, of Harvard University died on Sunday, November 10, 1946. Both men had given freely of their time and energy to advance mycology, and both had served as president of our Society. Detailed biographical accounts will appear in MYCOLOGIA in due time. A. H. Smith.

# MYCOLOGICAL SOCIETY OF AMERICA

## FINANCIAL STATEMENT, 1945

### Balance on hand, December 21, 1944:

Cash .....	\$ 957.23 .
Bonds .....	940.00
Savings account .....	241.31

Total ..... \$2138.54 \$2138.54

### Receipts:

Annual dues, part 1945, part 1946 .....	\$1720.00
Interest on savings account Purdue bank .....	3.62
Payment for one number "Mycologia" (Bitancourt) .....	1.50
Sale of bond coupons .....	51.93

Total ..... \$1777.05 \$1777.05

Grand Total ..... \$3915.59

### Expenditures:

Subscriptions to "Mycologia" .....	\$1656.00
One number of "Mycologia" (Bitancourt) .....	1.50
Mimeograph and printing .....	62.76
Subsidy for Whetzel paper .....	200.00
Secretarial help .....	6.00
Addressograph changes .....	8.64
Office supplies, phone, express, etc. ....	6.44
Bank charges .....	3.77
Postage (Secretary and Editor) .....	20.00
Face value loss on \$100 bond .....	.88
Adjustment on checks .....	1.22

Total ..... \$1967.21 \$1967.21

### Balance on hand December 31, 1945:

Cash .....	\$ 712.40
Savings account .....	395.98
Bonds .....	840.00

Total ..... \$1948.38 \$1948.38

Grand Total ..... \$3915.59

F. K. SPARROW, *Secretary Treasurer*

### Examined and found correct:

E. B. MAINS, *Chairman of Auditing Committee*  
April 25, 1946.

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<sup>1</sup> This index was prepared by Aurèle LaRocque.

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